PUBLISHED EVERY SATURDAY BY
THE W. J. JOHNSTON COMPANY, Limited,
167-177 TIMES BUILDING, NEW YORK.
Established 1874. Incorporated 1889.
Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York.

New England Office, Room 28, Hathaway Building, 620 Atlantic Ave., Boston.
Western Office, 465 The Rookery, Chicago.
Philadelphia Office, 927 Chestnut Street.

SUBSCRIPTION, IN ADVANCE, ONE YEAR, $3.
(Including Postage in the U. S., Canada or Mexico.)
IN CLUBS of four or more, $2.50 a year each; with a free extra copy to the getter up of a club of 8. Foreign subscription, $6 a year.

In requesting your address changed, d as well as new address.

ESTABLISHED 17 YEARS AGO, THE ELECTRICAL WORLD is the Pioneer Electrical Journal of America and has well maintained its lead. It has the LARGEST CIRCULATION of any electrical periodical in the world, and is the BEST ADVERTISING MEDIUM.

Correspondence, views and opinions on all topics within the province of this journal are cordially invited from any part of the world. We will thank readers to forward to us—**promptly** as they occur—**Items of News,** or information relating to any application of Electricity, also marked copies of their local papers containing anything likely to interest electricians. Anonymous communications cannot be noticed, nor can rejected manuscript be returned, unless accompanied by the necessary postage when received.

Advertising Rates are much lower than those of any other similar publication, circulation and standing considered, and vary according to space, position and number of insertions. Quotations promptly furnished. Situation or Help Wanted advertisements $1 to $2 an insertion, according to length.

Address all communications to
THE W. J. JOHNSTON COMPANY, Ltd.
Times Building, New York,
OR ANY OF THE BRANCH OFFICES.

VOL. XVII. NEW YORK, FEB. 21, 1891. No. 8.

CONTENTS.

EDITORIAL: PAGE
Paragraphs ... 12

ILLUSTRATED ARTICLES:
A Model Plant ... 126
The Dimensions of Crocker-Wheeler Motors ... 130
Electric Lighting in the Elgin Watch Factory ... 130
The Construction and Use of Electrical Testing Apparatus, by Chas. P. Frey ... 112
The Edison Company's Arc Plant at Long Island City ... 132
Lighting of the Metropolitan Opera House at St. Paul, by Clarence M. Tolman ... 133
Electricity in Transitu: from Plenum to Vacuum, by Prof. Wm. Crookes ... 134
Electromagnetic Mechanisms, by Prof. S. P. Thompson ... 135
Mitis Metal for Dynamo Magnets ... 137
Double Break Knife Switch ... 137
The Brewster Trolley Wire Clamp ... 137
The "E. E. & S." Rosette ... 137
A New Wire Covering Machine ... 137
The Factory of the Okonite Company ... 138

MISCELLANEOUS:
Latest Foreign Electrical News ... 126
Efficiency of Transformers, by Wm. Stanley, Jr. ... 128
Phenomena of Alternating Currents of Very High Frequency, by Nikola Tesla ... 128
Annual Report of the Federal Street and Pleasant Valley Railroad Company ... 131
High Pressure Transmission of Power Experiments ... 137
F. J. Sprague on Rapid Transit ... 143
Electrical Horse Power Tables ... 147

FINANCIAL INTELLIGENCE: The Electrical Stock Market, 138; New Incorporations, 139; Affairs of the Companies, 139.

SPECIAL CORRESPONDENCE: New York Notes, 139; New England Notes, 139; Western Notes, 139; Philadelphia Notes, 139; Southern Notes, 140; English Notes, 140.

NEWS OF THE WEEK: The Telegraph, 140; The Telephone, 140; The Electric Light, 140; The Electric Railway, 141; Personals, 141; Miscellaneous, 141.

INDUSTRIAL AND TRADE NOTES ... 141

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS ... 142

Rapid Transit in New York. IN a special supplement we present to our readers an elaborate discussion of the rapid transit problem by F. J. Sprague, who has long made it the subject of special study. Mr. Sprague is emphatically in favor of underground electric railroads as by all means the most practicable solution of the difficulty, and believes that the way and express services should be separated from each other and follow different routes. So many schemes are now before the public that the opinions of so competent an authority are peculiarly pertinent and valuable. As regards motive power, Mr. Sprague's opinion is emphatic. He holds, like most other competent engineers, that the electric motor not only should, but must, be used, if rapid transit is to become a reality.

Electrical Horse Power Tables. PERHAPS no computation has oftener to be performed by electrical engineers that the deduction of electrical horse power from ammeter and voltmeter readings. Unfortunately the relations between the electrical and mechanical units are not particularly simple, and where many readings are to be reduced the work becomes particularly tedious. To facilitate the process in their own work Dr. S. S. Wheeler and Prof. F. B. Crocker have compiled tables giving the electrical horse-powers for each volt and ampère over the range of values generally met, and through their courtesy we are enabled to present these in a supplement. It is printed on heavy paper fit for constant reference, and readily explains itself. We need only note that its practical range may be conveniently doubled either for volts or ampères by doubling the corresponding horse power so that it covers very simply all ordinary electrical work.

The Electric Light Convention. DURING the six months that have elapsed between the last assembling of the National Electric Light Convention and the present one, at which this number of THE ELECTRICAL WORLD will be distributed, there has been every reason for the electrical trades and industries to congratulate themselves. In spite of financial dullness electrical interests have, at least, held their own better than their neighbors, and have been going on in a steady course of expansion and improvement. It is a pleasant task to record all this, and THE ELECTRICAL WORLD feels that it can find no surer path to success and progress than in chronicling the good fortune of its friends and keeping pace with their advancement. In proof of this we may mention that the present issue is the largest one that THE ELECTRICAL WORLD has ever presented at such a meeting. To the National Electric Light Association in convention assembled, greeting: May the next half-year be even more fortunate and prosperous than the last has been.

A Typical Central Station. ON another page will be found a brief account of the splendid central station of the Narragansett Electric Lighting Company, at Providence, R. I., with illustrations of some of the principal features of the plant. It is one of the best examples of modern electrical engineering practice that has fallen under our notice, both in the care with which the plans were developed to permit of extensive additions and in the thoroughness with which the details of construction and equipment were carried out. The use of triple-expansion condensing engines of the largest size is perhaps the most striking as well as the most admirable feature of the installation. For a given amount of useful work accomplished, engines of this class require less than one-half the fuel needed with the more common types of machine, and unless in situations where fuel is exceedingly cheap, the modern engine will pay for itself in a very few years. It would be money in the pockets of many an electric light company if its engineer would carefully figure out the saving in fuel that could be accomplished by employing triple-expansion engines, and the stockholders were far-sighted enough to take advantage of the situation.

Transformer Design. IN another column we give a most interesting communication from Mr. William Stanley, Jr., with reference to certain transformers that have been tested at his laboratory. The object of the test was, it is needless to say, to find out what improvements could be introduced into the commercial transformer to secure a higher efficiency in service. It has been appreciated for some time that the secret of transformer efficiency was in good iron, and the efforts of most designers have been turned toward finding the kinds of iron that would give high permeability and low hysteresis. Mr. Stanley has been especially successful in this search, and the results are apparent in the tables that he gives. The actual efficiency of his transformer as tested is only a trifle in excess of others in every-day use, but the weight of the iron is enormously less than in the other transformers mentioned, and consequently, from very small hysteresis loss, the all-around efficiency at varying loads must be very unusually high. There is no especial mystery in the result Mr. Stanley has obtained. It simply represents a case of skillful design and of unusual care and successful experiments in obtaining and preparing an iron especially fitted for magnetic purposes. We shall be interested to learn more of these experiments of Mr. Stanley, and especially of the properties of the particular iron that he has employed. His results are certainly most satisfactory, and his suggestion of using larger transformer units to secure efficiency is one that we can heartily indorse; practice will inevitably tend in this direction. For not only can the larger sizes of transformer be made of a greater efficiency, but they can be, on the average, worked far nearer their point of maximum efficiency, for with a load of several hundred lights the fluctuations will be in general much less frequent and violent than where but few lamps are placed upon each transformer.

Cost of Electric Traction. ONE of the most instructive reports that it has been our fortune to see in a long time is that from the Pleasant Valley Electric Railroad Company, in Pittsburgh, which is published nearly in full in another column. It is worked out with the greatest care and exactness for the purpose of showing just what can be done by electric traction. It deserves the study of every one who is interested in that field of electrical progress; for while the results shown are not specially favorable, they are quite sufficient to show what can be done even under adverse conditions and to point out with great distinctness the means by which greater economy can be secured. The result showed that by changing from horses to electric motors the operating expenses per car mile were reduced about 10 per cent. At first sight they appear to be increased, but the true state of things appears when we separate the total running expenses so as to see what factors are characteristic of the use of electricity, what common to electricity and to horses, and which have increased not through the use of electricity, but through the extension of the system. A saving of 10 per cent., it should be said, is by no means as favorable as has appeared in certain cases. A few months ago THE ELECTRICAL WORLD sent out a confidential circular to electric railway managers calling for information on the very point so admirably explained in the report before us. As a result of the replies received we may confidently assert that a saving of considerably more than that shown in Pittsburgh is frequent on very many roads that have changed from horse power to electricity. Glancing at the report in detail one is instantly struck by the relatively small cost of the power generated, and the relatively large cost of repairs. Of the total cost of operation the portion due to supplying power was less than seven per cent., while the cost of electrical and mechanical repairs combined was more than 10 per cent., and about 20 per cent of the operating expenses proper. This cost of repairs is undoubtedly the weak point in electric traction as practiced to-day, and the ingenuity of inventors can be put to no better use than in lowering this item of expense. One important step in this direction has undoubtedly been made by employing lower speed motors and dispensing with the intermediate gear. Other improvements may be made in armature construction and insulation. But as the case now stands repairs are the most dangerous factor in operating an electric road. It ought to be said in this connection that these are in no sense a result of the overhead system, as they apply with equal force to motors and driving gear, whatever may be the source from which electricity is obtained. We wish that more managers of electric roads would come frankly out and give to the public such full and complete statements of the results of electrical operation as those we are discussing. There is much to be proud of in them, and it is from such sources that the material of progress can be best obtained.

An Important Research. WE publish this week one of the most valuable contributions to our knowledge of the properties and possibilities of alternating currents that has appeared for several years. The experiments of Mr. Nikola Tesla on alternating currents of almost transcendental frequency give a deep insight into one of the most extraordinary portions of electrical science. Mr. Tesla has worked with dynamos giving as high as 25,000 alternations per second, and consequently has within his grasp a class of phenomena that are only hinted at so long as experiments are confined to the frequencies in ordinary use. Not only is the work suggestive of practical results in the way of transforming by condensers, which with such frequencies becomes comparatively easy on account of the very small capacity required, but it is rich in suggestiveness as regards the relations between so-called electrical currents and the action that goes on in the dielectric. With a dynamo giving 20,000 or 25,000 alternations per second at an electromotive force of 500 volts, static effects became enormously enhanced. An immense amount of energy is distributed through the medium surrounding the machine, and in fact the experimenter may almost be said to be working in the dielectric of a condenser, of which the machine forms one surface and the surrounding walls the other. When incandescent lamps short-circuited by a bit of copper rod glow with intense brilliancy at some distance from the induction coil connected to the machine, Geissler tubes, unprovided with any terminals whatever, spring into brilliant radiance, and even an incandescent lamp grows hot when brought near the coil, the experimenter suddenly awakes from his dream of electrical energy as a thing carried along a wire into the almost appalling consciousness that the energy in the dielectric is really the only thing with which he has to do. We cannot in the brief space available in these columns give any adequate idea of the interest and beauty of the results that Mr. Tesla obtained in this novel line of work; the paper itself must be read and carefully re-read to appreciate the importance of the work. But even the striking experiments are of slight importance as compared with the theoretical results that are suggested by them. When displacement currents heretofore sought with almost negative results rise to a magnitude that heats the solid dielectric of the condenser almost to melting, one realizes with startling distinctness the truth of Maxwell's prophetic suggestions. Whatever may be our ultimate conception as to the nature of electricity, we are forced to the conclusion that the energy distributed through the dielectric is the all-important thing in electrical phenomena, and that the surface conditions that we know as electrification and current are comparatively subsidiary. Electrostatic induction and electromagnetic radiation seem simple, almost necessary, facts when we can work in a medium surcharged by the tremendous electrical stresses that make themselves evident in such a machine as that with which Mr. Tesla experimented. Even if this research should lead to no results of immediate commercial importance, it at least marks an epoch in scientific investigation by casting a flood of light upon phenomena that until now have existed merely as residual effects sought in vain by the experimenter, or noticed only as the concomitants of other and apparently more important electrical actions.

Latest Foreign Electrical News.

By Cable from THE ELECTRICAL WORLD'S *Regular Correspondent.*

LONDON, Feb. 14, 1891.—The Board of Trade last Tuesday printed the report that will be submitted on Friday next by the Electrical Standard Committee. The absolute system has been adopted fundamentally, the ohm, ampère and volt being legal units. The standard ohm will be taken from the latest determination of the mercury unit; that is, a column 106.3 centimetres long and one square millimetre in section at zero degrees centigrade. The material of the actual standard will be metal, and standards will be constructed corresponding to the new value. The standard current will be that depositing .001118 grams of silver per second, and passed through a 15 to 20 per cent. solution of silver nitrate. The standard instrument for current measurement is recommended to be on the balance principle, while the Clark cell will be taken as the proper standard for electromotive force determinations.

In the discussion on Gen. Webber's paper before the Institution of Electrical Engineers, Prof. Forbes and Mr. Crompton were the principal speakers; the latter vigorously attacked the Chelsea system of distribution as complicated and costly.

The Directors of the City & South London Railway Company in their annual report state that they have every reason to be satisfied with electricity as a motive power; that the generating plant, sidings and rolling stock will be increased immediately, so that when complete a regular three-minute service will be begun.

There has been a debate in the House of Commons on the subject of underground electric railway schemes recently proposed, and the question of demanding a royalty for the use of such has been raised.

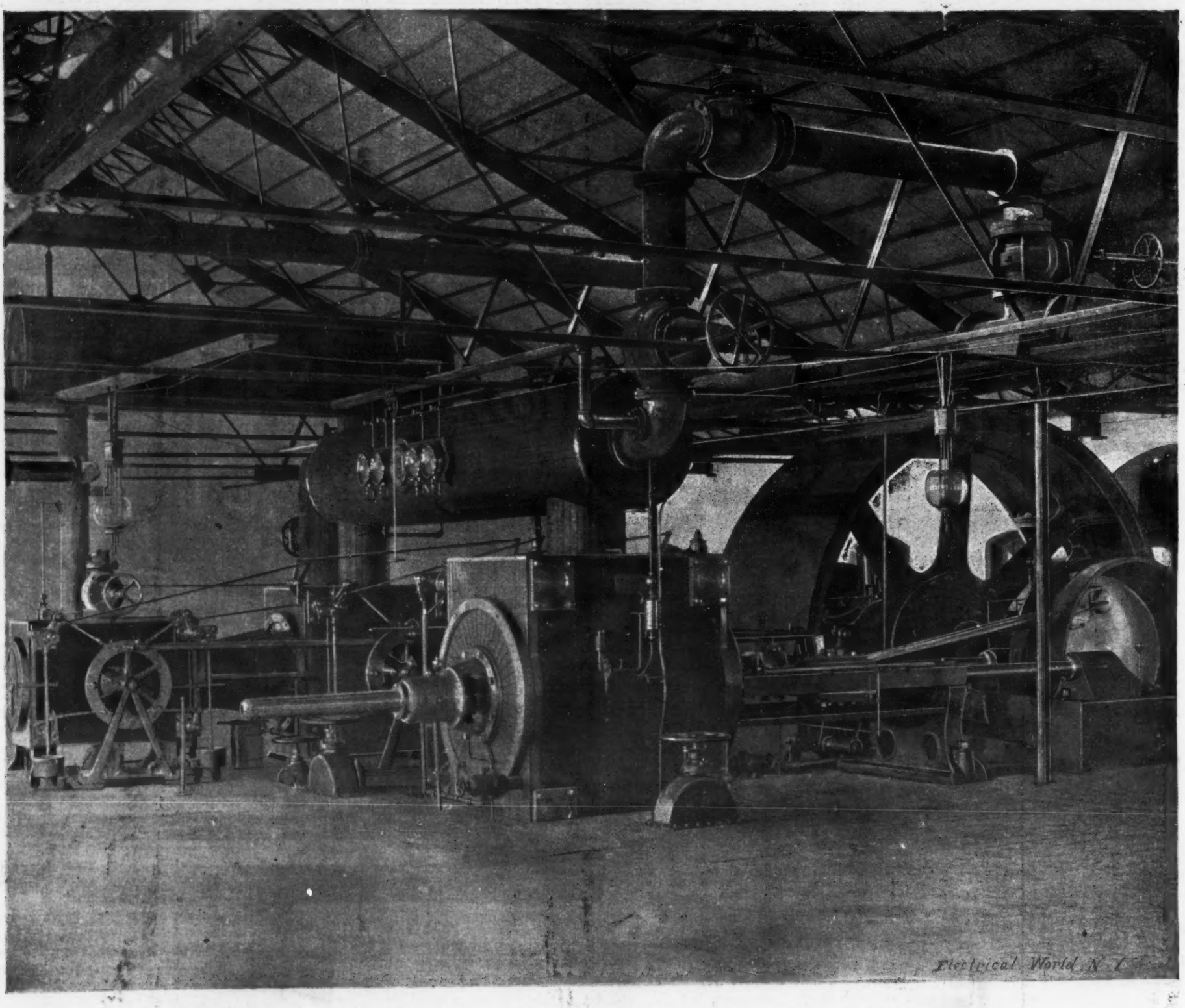
The Glasgow Municipality invites tenders for public lighting.

A Model Plant.

Few central stations for light and power present as good an example of the best modern practice as the great plant of the Narragansett Electric Lighting Company, in Providence, R. I. The company started about seven years ago, running at first only a few arc lamps for commercial lighting. Gradually the system spread; the contract for street lighting was acquired, and the system, ever increasing, gradually crept onward and outward through the entire extent of the city, until the company was crowded out of its old station and began the erection of the splendid structure that is its present headquarters. The site for the new station was selected on the water front close to the Providence River, where water for boilers and condensation was near at hand.

The structure consists of three distinct united buildings—a boiler house along the water front and an engine house, in which is located the gigantic chimney. Directly adjoining the engine house is the great room 200 feet long devoted to the dynamos. At the time of the present writing a little more than half of the total space is occupied, but extensions will probably progress with great rapidity. The boiler house as built is 68 × 72 feet and accommodates four batteries of boilers; it is so arranged, however, that it may be lengthened to nearly 200 feet. A very convenient arrangement connected with the boiler house is the coal pocket, which has a capacity of 25,000 tons and into which the coal is hoisted from the vessels, and dumped directly in front of the furnace doors. The boilers were made by the National Water Tube Boiler Company, of New Brunswick, N. J., and are of 250 h. p. each. The engine house is worthy of particular attention, as it stands unique among engine houses, not so much in the size of the machines installed as their remarkable character. The manager of the Narragansett Electric Light Company was far-sighted enough to see that large triple expansion engines of the latest type would do the work better and more economically than the small machines usually installed, and in facing the problem not the slightest hesitation was shown. The station up to the present has been operated by a single magnificent engine of the triple-expansion Corliss type, manufactured by the Allis Company, of Milwaukee, Wis. Occasional assistance is rendered by a small high-speed engine. Just at present, however, another engine has been put in use three times the size of the original one. The main engine is rated at 500 h. p.; it has three cylinders, 14, 25 and 33 inches diameter respectively, each of 48-inch stroke. The diameter of the main driving wheel is 17 feet in a 45-inch face, on which is run a 44-inch Schieren double belt that operates the main line shaft placed under the dynamo room in the adjacent dynamo house. The engine, after being in successful operation for some time, was given a most elaborate test for fuel economy, and the result was such as to afford ample encouragement to all central station managers to discontinue the use of high speed machines, except in special cases, and employ more generally engines of the most economical description. Under test this triple-expansion engine gave the indicated h. p. hour on 12.9 pounds of steam—a result which, although perhaps it does not represent the extreme limit of economy, is sufficiently near it to be exceedingly satisfactory to the users.

A new engine of the same type that has just been installed, and is exhibited in our cut, is a 1,500 h. p. Its cylinders are respectively 21, 36 and 50 inches in diameter by 48 inches stroke, and it drives a 16-foot fly wheel 73 inches across the face and carrying a 72-inch belt. It is in almost all respects the duplicate, except in size, of the machine previously installed, and will doubtless show even better results under testing. Besides these large engines one



ENGINE ROOM OF THE NARRAGANSETT ELECTRIC LIGHTING COMPANY'S STATION AT PROVIDENCE, R. I.

DYNAMO AND BOILER ROOMS OF THE NARRAGANSETT. ELECTRIC LIGHTING COMPANY'S STATION AT PROVIDENCE, R. I.

150 h. p. Armington & Sims high speed engine is employed for special service. The line shaft is placed in the lower story of the dynamo house; it is six inches in diameter and carries pulleys for driving all the dynamos. It is not connected directly to the engines, but the latter are belted to jack pulleys on hollow shafts, through which the main shaft passes. They are connected to the latter by friction clutches; the one now used being a Hill clutch 54 inches in diameter and capable of transmitting 500 h. p.

The dynamo house is 60 feet wide and 200 feet long, with heavy walls rising nearly 30 feet, thus giving, aside from the basement in which the shafting is located, a dynamo room 17 feet high to the underside of the truss roof. This, like the roof of the engine house, is of wrought iron built by the Berlin Iron Bridge Company. The dynamos are on the main floor of the building, just above the shaft. They are in number 41; 35 of them are Thomson-Houston arc dynamos with a total capacity of 1,450 lamps, of which about 1,300 are in circuit. The incandescent department is presided over by five Westinghouse alternators capable of an aggregate output of 10,500 lamps, of which nearly 9,000 are in circuit. The incandescent lamp service is entirely by meter. Besides this a 500 volt Thomson-Houston generator is operated on a motor circuit now running 88 machines with a total capacity of 229 h. p. The circuits of the company include, all told, 300 miles of wiring work that is a model of its kind. This brief sketch will give a rough idea of the many good points of what is in most respects a model station. It furnishes the most magnificent exhibit displayed at the present meeting of the National Electric Light Association.

Efficiency of Transformers.

BY WILLIAM STANLEY, JR.

The following data, taken from tests made at the Stanley Laboratory at Pittsfield, may be of interest to engineers. The transformers are presumably of the latest design, as they are entirely new, and obtained from the manufacturer within the last thirty days. The method adopted for obtaining the hysteresis and Foucault losses was the sam as that given by Blakesley, known as Blakesley's split dynamometer method of determining lag, which, while it is not absolute and cannot be relied upon for very accurate measurements, is sufficiently proximate for commercial work and affords a reliable basis of comparison between the several transformers. It is unfortunate that two of the transformers were of larger size than the others, for it is comparatively easy to design a 1,200-watt transformer to have an efficiency one per cent. greater than a 1,000-watt transformer designed with equal care would have. The weights of the active iron in the transformers tested varied 100 per cent. for a given output. It should be borne in mind that the column marked "maximum efficiency" represents in reality lower values than actually are obtained in practice, because the total loss in a transformer is not the sum of the loss by hysteresis and the C^2R losses, measured when the performer is doing no work, but is less than the sum of these losses, because the hysteresis loss falls off as the load is increased upon the secondary, and generally that the figures are not intended for more than comparative results. All transformers tested converted from 1,000 to 50 volts. In all tested, save the Thomson-Houston transformer, the current was taken from one of the Westinghouse Company's alternators at a frequency of 138 periods per second. In the case of the Thomson-Houston transformer, it was tested with the current from a Thomson Houston machine at 125 periods per second.

Column 1 gives the type and size of transformer; column 2, the current passing through the transformer when the secondary was open; column 3, the potential on the primary; column 4, the C^2R loss in primary and secondary circuits; column 5, the percentage drop below normal potential on the secondary circuit at full load; column 6, the hysteresis and Foucault losses; column 7, the efficiencies at full load, estimated from columns 4 and 6 together. A schedule of the weights of the transformers is appended. It is important to notice that the watts lost per pound of iron in these transformers varies from 1.1 watts to .3 watt per pound. As has been mentioned, the size of the transformer is an important item in estimating its efficiency. The transformer marked "Slattery," 25-light size (1,250 watts), attains a maximum efficiency of 94.0 per cent., principally because, being of 25 per cent. greater capacity, its copper and iron are more efficiently used. Certain transformers designed by the writer of 1,500-watt capacity exceed 96 per cent. efficiency estimated on the same basis as those in the table.

This fact, viz., that the efficiency of a transformer is a function of its capacity, clearly indicates that the transformers of large capacity should be in general use, as it is comparatively easy to design them of 5,000 to 10,000 watts capacity at an efficiency of 97½ per cent., while it is far more difficult to design a 250-watt transformer at an efficiency of 90 per cent.

Type.	Size.	Leakage cur.	E. M. F.	Total C^2R.	Drop.	Hys.	Max. eff.
Stanley.....	20-light	.053 amp.	1,000 volts.	19.25	1.9	37.5	94.3
W'house....	20 "	.061 "	1,000 "	20.8	2.1	48.	93.1
Slattery	25 "	.056 "	1,000 "	30.2	2.	45.5	94.
National....	20 "	.112 "	1,000 "	24.3	2.4	75.	90.1
T.-H.	25 "	.213 "	1,000 "	27.	1.8	129.3	87.5

Total weight.....	Stanley	(20-light)	46 pounds (without case.)
" "	Slattery	(25-light)	121 "
" "	National	(20-light)	81 "
" "	T.-H.	(25-light)	145 "
" "	W'house	(20-light)	85 "

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

ALTERNATE CURRENT MACHINES OF HIGH FREQUENCY; CURIOUS EXPERIMENTS WITH GEISSLER TUBES AND LAMPS; AN EXPLODED NOTION; NOISELESS ALTERNATING ARCS; CONSTANT CURRENT AND CONSTANT POTENTIAL; INTERESTING EXPERIMENT WITH A CONDENSER; THE FERRANTI-MAIN EFFECT; DA LIEGT DER HASE IM PFEFFER BEGRABEN; SUGGESTIONS OF MR. SWINBURNE.

Electrical journals are getting to be more and more interesting. New facts are observed and new problems spring up daily which command the attention of engineers. In the last few numbers of the English journals, principally in the *Electrician*, there have been several new matters brought up which have attracted more than usual attention. The address of Professor Crookes has revived the interest in his beautiful and skillfully performed experiments, the effect observed on the Ferranti mains has elicited the expressions of opinion of some of the leading English electricians, and Mr. Swinburne has brought out some interesting points in connection with condensers and dynamo excitation.

The writer's own experiences have induced him to venture a few remarks in regard to these and other matters, hoping that they will afford some useful information or suggestion to the reader.

Among his many experiments Professor Crookes shows some performed with tubes devoid of internal electrodes, and from his remarks it must be inferred that the results obtained with these tubes are rather unusual. If this be so, then the writer must regret that Professor Crookes, whose admirable work has been the delight of every investigator, should not have availed himself in his experiments of a properly constructed alternate current machine—namely, one capable, of giving, say, 10,000 to 20,000 alternations per second. His researches on this difficult but fascinating subject would then have been even more complete. It is true that when using such a machine in connection with an induction coil the distinctive character of the electrodes—which is desirable, if not essential, in many experiments—is lost, in most cases both the electrodes behaving alike; but, on the other hand, the advantage is gained that the effects may be exalted at will. When using a rotating switch or commutator the rate of change obtainable in the primary current is limited. When the commutator is more rapidly revolved the primary current diminishes, and if the current be increased, the sparking, which cannot be completely overcome by the condenser, impairs considerably the virtue of the apparatus. No such limitations exist when using an alternate current machine, as any desired rate of change may be produced in the primary current. It is thus possible to obtain excessively high electromotive forces in the secondary circuit with a comparatively small primary current; moreover, the perfect regularity in the working of the apparatus may be relied upon.

The writer will incidentally mention that any one who attempts for the first time to construct such a machine will have a tale of woe to tell. He will first start out, as a matter of course, by making an armature with the required number of polar projections. He will then get the satisfaction of having produced an apparatus which is fit to accompany a thoroughly Wagnerian opera. It may besides possess the virtue of converting mechanical energy into heat in a nearly perfect manner. If there is a reversal in the polarity of the projections, he will get heat out of the machine; if there is no reversal, the heating will be less, but the output will be next to nothing. He will then abandon the iron in the armature, and he will get from the Scylla to the Charybdis. He will look for one difficulty and will find another, but, after a few trials, he may get nearly what he wanted.

Among the many experiments which may be performed with such a machine, of not the least interest are those performed with a high-tension induction coil. The character of the discharge is completely changed. The arc is established at much greater distances, and it is so easily affected by the slightest current of air that it often wriggles around in the most singular manner. It usually emits the rhythmical sound peculiar to the alternate current arcs, but the curious point is that the sound may be heard with a number of alternations far above ten thousand per second, which by many is considered to be about the limit of audition. In many respects the coil behaves like a static machine. Points impair considerably the sparking interval, electricity escaping from them freely, and from a wire attached to one of the terminals streams of light issue, as though it were connected to a pole of a powerful Toepler machine. All these phenomena are, of course, mostly due to the enormous differences of potential obtained. As a consequence of the self-induction of the coil and the high frequency, the current is minute while there is a corresponding rise of pressure. A current impulse of some strength started in such a coil should persist to flow no less than four ten-thousandths of a second. As this time is greater than half the period it occurs that an opposing electromotive force begins to act while the current is still flowing. As a consequence, the pressure rises as in a tube filled with liquid and vibrated rapidly around its axis. The current is so small that, in the opinion and involuntary experience of the writer, the discharge of even a very large coil cannot produce seriously injurious effects, whereas, if the same coil were operated with a current of lower frequency, though the electromotive force would be much smaller, the discharge would be most certainly injurious. This result, however, is due in part to the high frequency. The writer's experiences tend to show that the higher the frequency the greater the amount of electrical energy which may be passed through the body without serious discomfort; whence it seems certain that human tissues act as condensers.

One is not quite prepared for the behavi or of the coil when connected to a Leyden jar. One, of course, anticipates that since the frequency is high the capacity of the jar should be small. He therefore takes a very small jar, about the size of a small wine-glass, but he finds that even with this jar the coil is practically short-circuited. He then reduces the capacity until he comes to about the capacity of two spheres, say, ten centimetres in diameter and two to four centimetres apart. The discharge then assumes the form of a serrated band exactly like a succession of sparks viewed in a rapidly revolving mirror; the serations, of course, corresponding to the condenser discharges. In this case one may observe a queer phenomenon. The discharge starts at the nearest points, works gradually up, breaks somewhere near the top of the spheres, begins again at the bottom, and so on. This goes on so fast that several serrated bands are seen at once. One may be puzzled for a few minutes, but the explanation is simple enough. The discharge begins at the nearest points, the air is heated and carries the arc upward until it breaks, when it is re-established at the nearest points, etc. Since the current passes easily through a condenser of even small capacity, it will be found quite natural that connecting only one terminal to a body of the some size, no matter how well insulate , impairs considerably the striking distance of the arc.

Experiments with Geissler tubes are of special interest. An exhausted tube, devoid of electrodes of any kind, will light up at some distance from the coil. If a tube from a vacuum pump is near the coil the whole of the pump is brilliantly lighted. An incandescent lamp approached to the coil lights up and gets perceptibly hot. If a lamp have the terminals connected to one of the binding posts of the coil and the hand is approached to the bulb, a very curious and rather unpleasant discharge from the glass to the hand takes place, and the filament may become incandescent. The discharge resembles to some extent the stream issuing fr om the plates of a powerful Toepler machine, but is of incomparably greater quantity. The lamp in this case acts as a condenser, the rarefied gas being one coating, the operator's hand the other. By taking the globe of a lamp in the hand, and by bringing the metallic terminals near to or in contact with a conductor connected to the coil, the carbon is brought to bright incandescence and the glass is rapidly heated. With a 100-volt 10 c. p. lamp one may without great discomfort stand as much current as will bring the lamp to a considerable brilliancy; but it can be held in the hand only for a few minutes as the glass is heated in an incredibly short time. When a tube is lighted by bringing it near to the coil it may be made to go out by interposing a metal plate or the hand between the coil and tube; but if the metal plate be fastened to a glass rod or otherwise insulated, the tube may remain lighted if the plate be interposed, or may even increase in luminosity. The effect depends on the position of the plate and tube relatively to the coil and may be always easily foretold by *assuming* that conduction takes place from one terminal of the coil to the other. According to the position of the plate, it may either divert from or direct the current to the tube.

In another line of work the writer has in frequent experiments maintained incandescent lamps of 50 or 100 volts burning at any desired candle power with both the terminals of each lamp connected to a stout copper wire of no more than a few feet in length. These experiments seem interesting enough, but they are not more so than the queer experi ment of Faraday, which has been revived and made much of by recent investigators, and in which a discharge is made to jump between two points of a bent copper wire. An experiment may be cited here which may seem equally interesting. If a Geissler tube, the terminals of which are joined by a copper wire, be approached to the coil, certainly no one would be prepared to see the tube light up. Curiously enough, it does light up, and, what is more, the wire does not seem to make much difference. Now one is apt to think in the first moment that the impedance of the wire might have something to do with the phenomenon. But this is of course immediately rejected, as for this an enormous frequency would be required. The result, however, seems puzzling only at first; for upon reflection it is quite clear that the wire can make but little difference. It may be explained in more than one way, but it agrees perhaps best with observation to assume that conduction takes place from the terminals of the coil through the space. On this assumption, if the tube with the wire be held in any position, the wire can divert little more than the current which passes through the space occupied by the wire and the metallic terminals of the tube; through the adjacent space the current passes practically undisturbed. For this reason, if the tube be held in any position at right angles to the line joining the binding posts of the coil, the wire makes hardly any difference, but in a position more

or less parallel with that line it impairs to a certain extent the brilliancy of the tube and its facility to light up. Numerous other phenomena may be explained on the same assumption. For instance, if the ends of the tube be provided with washers of sufficient size and held in the line joining the terminals of the coil, it will not light up, as then nearly the whole of the current; which would otherwise pass uniformly through the space between the washers, is diverted through the wire. But if the tube be inclined sufficiently to that line, it will light up in spite of the washers. Also, if a metal plate be fastened upon a glass rod and held at right angles to the line joining the binding posts, and nearer to one of them, a tube held more or less parallel with the line will light up instantly when one of its terminals touches the plate and will go out when separated from the plate. The greater the surface of the plate up to a certain limit, the easier the tube will light up. When a tube is placed at right angles to the straight line joining the binding posts, and then rotated, its luminosity steadily increases until it is parallel with that line. The writer must state, however, that he does not favor the idea of a leakage or current through the space any more than as a suitable explanation, for he is convinced that all these experiments could not be performed with a static machine yielding a constant difference of potential, and that condenser action is largely concerned in these phenomena.

It is well to take certain precautions when operating a Ruhmkorff coil with very rapidly alternating currents. The primary current should not be turned on too long, else the core may get so hot as to melt the gutta-percha or paraffin, or otherwise injure the insulation, and this may occur in a surprisingly short time, the current's strength considered. The primary current being turned on, the fine wire terminals may be joined without great risk, the impedence being so great that it is difficult to force enough current through the fine wire so as to injure it, and in fact the coil may be on the whole much safer when the terminals of the fine wire are connected than when they are insulated; but special care should be taken when the terminals are connected to the coatings of a Leyden jar, for with anywhere near the critical capacity, which just counteracts the self-induction at the existing frequency, the coil might meet the fate of St. Polycarpus. If an expensive vacuum pump is lighted up by being near to the coil or touched with a wire connected to one of the terminals, the current should be left on no more than a few moments, else the glass will be cracked by the heating of the rarefied gas in one of the narrow passages—in the writer's own experience *quod erat demonstrandum.**

There are a good many other points of interest which may be observed in connection with such a machine. Experiments with the telephone, a conductor in a strong field or with a condenser or arc seem to afford certain proof that sounds far above the usual accepted limit of hearing would be perceived. A telephone will emit notes of twelve to thirteen thousand vibrations per second, then the inability of the core to follow such rapid alternations begins to tell. If, however, the magnet and core be replaced by a condenser and the terminals connected to the high-tension secondary of a transformer higher notes may still be heard. If the current be sent around a finely laminated core and a small piece of thin sheet iron be held gently against the core, a sound may be still heard with thirteen to fourteen thousand alternations per second, provided the current is sufficiently strong. A small coil, however, tightly packed between the poles of a powerful magnet, will emit a sound with the above number of alternations, and arcs may be audible with still a higher frequency. The limit of audition is variously estimated. In Sir William Thomson's writings it is stated somewhere that ten thousand per second, or nearly so, is the limit. Other, but less reliable, sources give it as high as twenty four thousand per second. The above experiments have convinced the writer that notes of an incomparably higher number of vibrations per second would be perceived provided they could be produced with sufficient power. There is no reason why it should not be so. The condensations and rarefactions of the air would necessarily set the diaphragm in a corresponding vibration and some sensation would be produced whatever—within certain limits—the velocity of transmission to their nerve centres, though it is probable that for want of exercise the ear would not be able to distinguish any such high note. With the eye it is different; if the sense of vision is based upon some resonance effect, as many believe, no amount of increase in the intensity of the ethereal vibration could extend our range of vision on either side of the visible spectrum.

The limit of audition of an arc depends on its size. The greater the surface by a given heating effect in the arc the higher the limit of audition. The highest notes are emitted by the high-tension discharges of an induction coil in which the arc is, so to speak, all surface. If R be the resistance of an arc, and C the current, and the linear dimensions be n times increased, then the resistance is $\frac{R}{n}$, and with the same current density the current would be n^2C; hence the heating effect is n^3 times greater, while the surface is only n^2 times as great. For this reason very large arcs would not emit any rhythmical sound even with a very low frequency. It must be observed, however, that the sound emitted depends to some extent also on the composition of the carbon. If the carbon contain highly refractory material, this when heated tends to maintain the temperature of the arc uniform and the sound is lessened; for this reason it would seem that an alternating arc requires such carbons.

With currents of such high frequencies it is possible to obtain noiseless arcs, but the regulation of the lamp is rendered extremely difficult on account of the excessively small attractions or repulsions between conductors conveying these currents.

An interesting feature of the arc produced by these rapidly alternating currents is its persistency. There are two causes for it, one of which is always present, the other sometimes only. One is due to the character of the current and the other to a property of the machine. The first cause is the more important one, and is due directly to the rapidity of the alternations. When an arc is formed by a periodically undulating current, there is a corresponding undulation in the temperature of the gaseous column, and, therefore, a corresponding undulation in the resistance of the arc. But the resistance of the arc varies enormously with the temperature of the gaseous column, being practically infinite when the gas between the electrodes is cold. The persistence of the arc, therefore, depends on the inability of the column to cool. It is for this reason impossible to maintain an arc with the current alternating only a few times a second. On the other hand, with a practically continuous current, the arc is easily maintained, the column being constantly kept at a high temperature and low resistance. The higher the frequency the smaller the time interval during which the arc may cool and increase considerably in resistance. With a frequency of 10,000 per second or more in an arc of same size excessively small variations of temperature are superimposed upon a steady temperature, like ripples on the surface of a deep sea. The heating effect is practically continuous and the arc behaves like one produced by a continuous current, with the exception, however, that it may not be quite as easily started, and that the electrodes are equally consumed; though the writer has observed some irregularities in this respect.

The second cause alluded to, which possibly may not be present, is due to the tendency of a machine of such high frequency to maintain a practically constant current. When the arc is lengthened the electromotive force rises in proportion and the arc appears to be more persistent.

Such a machine is eminently adapted to maintain a constant current, but it is very unfit for a constant potential. As a matter of fact, in certain types of such machines a nearly constant current is an almost unavoidable result. As the number of poles or polar projections is greatly increased, the clearance becomes of great importance. One has really to do with a great number of very small machines. Then there is the impedence in the armature, enormously augmented by the high frequency. Then, again, the magnetic leakage is facilitated. If there are three or four hundred alternate poles the leakage is so great that it is virtually the same as connecting, in a two-pole machine, the poles by a piece of iron. This disadvantage, it is true, may be obviated more or less by using a field throughout of the same polarity, but then one encounters difficulties of a different nature. All these things tend to maintain a constant current in the armature circuit.

In this connection it is interesting to notice that even to-day engineers are astonished at the performance of a constant current machine, just as, some years ago, they used to consider it an extraordinary performance if a machine was capable of maintaining a constant potential difference between the terminals. Yet one result is just as easily secured as the other. It must only be remembered that in an inductive apparatus of any kind, if constant potential is required, the inductive relation between the primary or exciting and secondary or armature circuit must be the closest possible; whereas, in an apparatus for constant current just the opposite is required. Furthermore, the opposition to the current's flow in the induced circuit must be as small as possible in the former and as great as possible in the latter case. But opposition to a current's flow may be caused in more than one way. It may be caused by ohmic resistance or self induction. One may make the induced circuit of a dynamo machine or transformer of such high resistance that when operating devices of considerably smaller resistance within very wide limits a nearly constant current is maintained. But such high resistance involves a great loss in power, hence it is not practicable. Not so self-induction. Self-induction does not necessarily mean loss of power. The moral is, use self-induction instead of resistance. There is, however, a circumstance which favors the adoption of this plan, and this is, that a very high self-induction may be obtained cheaply by surrounding a comparatively small length of wire more or less completely with iron, and, furthermore, the effect may be exalted at will by causing a rapid undulation of the current. To sum up, the requirements for constant current are: Weak magnetic connection between the induced and inducing circuits, greatest possible self-induction with the least resistance, greatest practicable rate of change of the current. Constant potential, on the other hand, requires: Closest magnetic connection between the circuits, steady induced current, and, if possible, no reaction. If the latter conditions could be fully satisfied in a constant potential machine, its output would surpass many times that of a machine primarily designed to give constant current. Unfortunately, the type of machine in which these conditions may be satisfied is of little practical value, owing to the small electromotive force obtainable and the difficulties in taking off the current.

With their keen inventor's instinct, the now successful arc-light men have early recognized the desideratums of a constant current machine. Their arc light machines have weak fields, large armatures, with a great length of copper wire and few commutator segments to produce great variations in the current's strength and to bring self-induction into play. Such machines may maintain within considerable limits of variation in the resistance of the circuit a practically constant current. Their output is of course correspondingly diminished, and, perhaps, with the object in view not to cut down the output too much, a simple device compensating exceptional variations is employed. The undulation of the current is almost essential to the commercial success of an arc-light system. It introduces in the circuit a steadying element taking the place of a large ohmic resistance, without involving a great loss in power, and, what is more important, it allows the use of simple clutch lamps, which with a current of a certain number of impulses per second, best suitable for each particular lamp, will, if properly attended to, regulate even better than the finest clock-work lamps. This discovery has been made by the writer—several years too late.

It has been asserted by competent English electricians that in a constant current machine or transformer the regulation is effected by varying the phase of the secondary current. That this view is erroneous may be easily proved by using, instead of lamps, devices each possessing self-induction and capacity or self-induction and resistance—that is, retarding and accelerating components—in such proportions as to not affect materially the phase of the secondary current. Any number of such devices may be inserted or cut out, still it will be found that the regulation occurs, a constant current being maintained while the electromotive force is varied with the number of the devices. The change of phase of the secondary current is simply a result following from the changes in resistance, and, though secondary reaction is always of more or less importance, yet the real cause of the regulation lies in the existence of the conditions above enumerated. It should be stated, however, that in the case of a machine the above remarks are to be restricted to the cases in which the machine is independently excited. If the excitation be effected by commutating the armature current, then the fixed position of the brushes makes any shifting of the neutral line of the utmost importance, and it may not be thought immodest of the writer to mention that, as far as records go he seems to have been the first who has successfully regulated machines in providing a bridge connection between a point of the external circuit and the commutator by means of a third brush. The armature and field being properly proportioned and the brushes placed in their determined positions, a constant current or constant potential resulted from the shifting of the diameter of commutation by the varying loads.

In connection with machines of such high frequencies the condenser affords an especially interesting study. It is easy to raise the electromotive force of such a machine to four or five times the value by simply connecting the condenser to the circuit, and the writer has continually used the condenser for the purposes of regulation as suggested by Blakesley in his book on alternate currents, in which he has treated the most frequently occurring condenser problems with exquisite simplicity and clearness. The high frequency allows the use of small capacities and renders investigation easy. But, although in most of the experiments the result may be foretold, yet some phenomena observed seem at first curious. One experiment performed three or four months ago with such a machine and a condenser may serve as illustration. A machine was used giving about 20,000 alternations per second. Two bare wires of about 20 feet long and two millimetres diameter, in close proximity to each other, were connected to the terminals of the machine on the one end, and to a condenser on the other. A small transformer without an iron core, of course, was used to bring the reading within the range of a Cardew voltmeter by connecting the voltmeter to the secondary. On the terminals of the condenser the electromotive force was about 120 volts, and from there inch by inch it gradually fell until on the terminals of the machine it was about 65 volts. It was virtually as though the condenser were a generator, and the line and armature circuit simply a resistance connected to it. The writer looked for a case of resonance, but he was unable to augment the effect by varying the capacity very carefully and gradually or by changing the speed of the machine. A case of pure resonance he was unable to obtain. When a condenser was connected to the terminals of the machine—the self-induction of the armature being first determined in the maximum and minimum position and the mean value taken—the capacity which gave the highest electromotive force corresponded most nearly to that which just

* It is thought necessary to remark that, although the induction coil may give quite a good result when operated with such rapidly alternating currents, yet its construction, quite irrespective of the iron core, makes it very unfit for such high frequencies, and to obtain the best results the construction should be greatly modified

counteracted the self-induction with the existing frequency. If the capacity was increased or diminished the electromotive force fell as expected.

With frequencies as high as the above mentioned the condenser effects are of enormous importance. The condenser becomes a highly efficient apparatus capable of transferring considerable energy.

The writer has thought that machines of high frequencies may find use at least in cases when transmission at great distances is not contemplated. The increase of the resistance may be reduced in the conductors and exalted in the devices when heating effects are wanted, transformers may be made of higher efficiency and greater outputs and valuable results may be secured by means of condensers. In using machines of high frequency the writer has been able to observe condenser effects which would have other wise escaped his notice. He has been very much interested in the phenomenon observed on the Ferranti main which has been so much spoken of. Opinions have been expressed by competent electricians, but up to the present all still seems to be conjecture. Undoubtedly in the views expressed the truth must be contained, but as the opinions differ some must be erroneous. Upon seeing the diagram of M. Ferranti in the *Electrician* of Dec. 19 the writer has formed his opinion of the effect. In the absence of all the necessary data he must content himself to express in words the process which, in his opinion, must undoubtedly occur. The condenser brings about two effects: (1) It changes the phases of the currents in the branches; (2) it changes the strength of the currents. As regards the change in phase, the effect of the condenser is to accelerate the current in the secondary at Deptford and to retard it in the primary at London. The former has the effect diminishing the self-induction in the Deptford primary, and this means lower electromotive force on the dynamo. The retardation of the primary at London, as far as merely the phase is concerned, has little or no effect since the phase of the current in the secondary in London, is not arbitrarily kept.

Now, the second effect of the condenser is to increase the current in both the branches. It is immaterial whether there is equality between the currents or not; but it is necessary to point out, in order to see the importance of the Deptford step-up transformer, that an increase of the current in both the branches produces opposite effects. At Deptford it means further lowering of the electromotive force at the primary, and at London it means increase of the electromotive force at the secondary. Therefore, all the things co-act to bring about the phenomenon observed. Such actions, at least, have been formed to take place under similar conditions. When the dynamo is connected directly to the main, one can see that no such action can happen.

The writer has been particularly interested in the suggestions and views expressed by Mr. Swinburne. Mr. Swinburne has frequently honored him by disagreeing with his views. Three years ago, when the writer, against the prevailing opinion of engineers, advanced an open circuit transformer, Mr. Swinburne was the first to condemn it by stating in the *Electrician*: "The (Tesla) transformer must be inefficient; it has magnetic poles revolving, and has thus an *open* magnetic circuit." Two years later Mr. Swinburne becomes the champion of the open circuit transformer, and offers to convert him. But, *tempora mutantur et nos mutamur in illis.*

The writer cannot believe in the armature reaction theory as expressed in *Industries*, though undoubtedly there is some truth in it. Mr. Swinburne's interpretation, however, is so broad that it may mean anything.

Mr. Swinburne seems to have been the first who has called attention to the heating of the condensers. The astonishment expressed at that by the ablest electrician is a striking illustration of the desirability to execute experiments on a large scale. To the scientific investigator, who deals with the minutest quantities, who observes the faintest effects, far more credit is due than to one who experiments with apparatus on an industrial scale; and indeed history of science has recorded examples of marvelous skill, patience and keenness of observation. But however great the skill, and however keen the observer's perception, it can only be of advantage to magnify an effect and thus facilitate its study. Had Faraday carried out but one of his experiments on dynamic induction on a large scale it would have resulted in an incalculable benefit.

In the opinion of the writer, the heating of the condensers is due to three distinct causes: first, leakage or conduction; second, imperfect elasticity in the dielectric, and, third, surging of the charges in the conductor.

In many experiments he has been confronted with the problem of transferring the greatest possible amount of energy across a dielectric. For instance, he has made incandescent lamps the ends of the filaments being completely sealed in glass, but attached io interior condenser coatings so that all the energy required had to be transferred across the glass with a condenser surface of no more than a few centimetres square. Such lamps would be a practical success with sufficiently high frequencies. With alternations as high as 15,000 per second it was easy to bring the filaments to incandescence. With lower frequencies this could also be effected, but the potential difference had, of course, to be increased. The writer has then found that the glass gets, after a while, perforated and the vacuum is impaired. The higher the frequency the longer the lamp can withstand. Such a deterioration of the deelectric always takes place when the amount of energy transferred across a dielectric of definite dimensions and by a given frequency is too great. Glass withstands best, but even glass is deteriorated. In this case the potential difference on the plates is of course too great and losses by conduction and imperfect elasticity result. If it is desirable to produce condensers capable to stand great differences of potential, then the only dielectric which will involve no losses is a gas under pressure. The writer has worked with air under enormous pressures, but there a are great many practical difficulties in that direction. He thinks that, in order to make the condensers of considerable practical utility, higher frequencies should be used; though such a plan has besides others the great disadvantage that the system would become very unfit for the operation of motors.

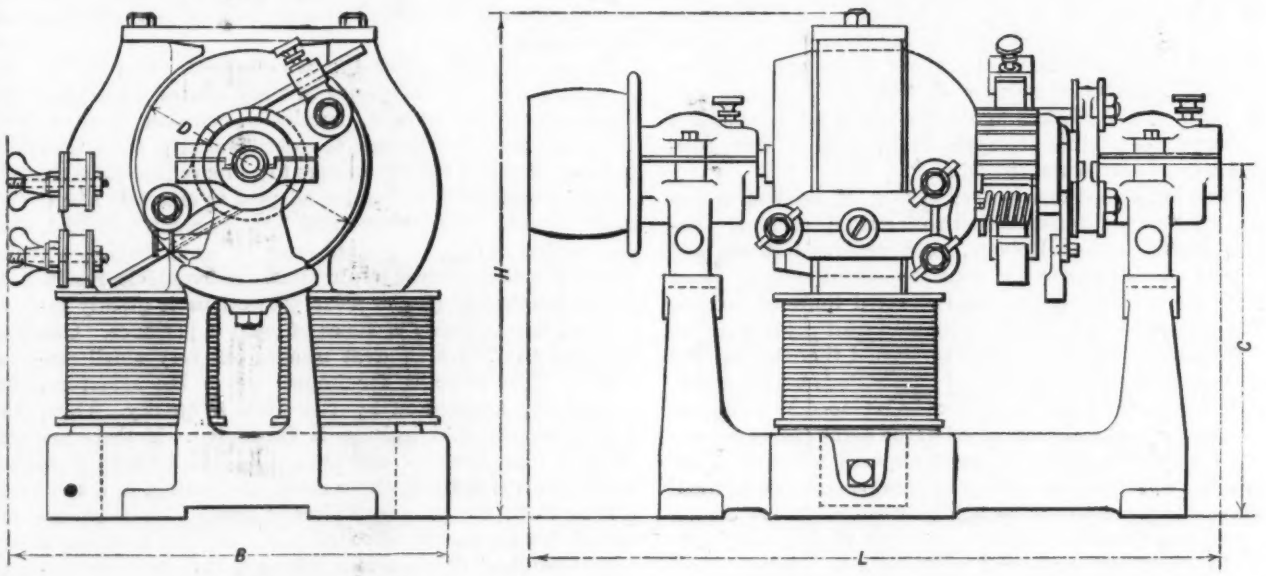
If the writer does not err, Mr. Swinburne has suggested a way of exciting an alternator by means of a condenser. For a number of years past the writer has carried on experiments with the object in view of producing a practical self-exciting alternator. He has in a variety of ways succeeded in producing some excitation of the magnets by means of alternating currents, which were not commutated by mechanical devices. Nevertheless, his experiments have revealed a fact which stands as solid as the rock of Gibraltar. No practical excitation can be obtained with a single periodically varying and not commutated current. The reason is that the changes in the strength of the exciting current produce corresponding changes in the field strength, with the result of inducing currents in the armature; and these currents interfere with those produced by the motion of the armature through the field, the former being a quarter phase in advance of the latter. If the field be laminated, no excitation can be produced; if it be not laminated, some excitation is produced, but the magnets are heated. By combining two exciting currents displaced by a quarter phase, excitation may be produced in both cases, and if the magnet be not laminated the heating effect is comparatively small, as a uniformity in the field strength is maintained, and, were it possible to produce a perfectly uniform field, excitation on this plan would give quite practical results. If such results are to be secured by the use of a condenser, as suggested by Mr. Swinburne, it is necessary to combine two circuits separated by a quarter phase; that is to say, the armature coils must be wound in two sets and connected to one or two independent condensers. The writer has done some work in that direction, but must defer the description of the devices for some future time.

TABLE OF DIMENSIONS AND OTHER DATA OF THE CROCKER-WHEELER MOTORS.

[Horse power.	Net weight, lbs.	Speed.	Pulley. "P." Diameter, ins.	Pulley. "F." Face, ins.	Size of motor over all. "L." Length ins.	"B." Breadth, ins.	"H." Height ins.	"G." Length between bolt holes in base.	"E." Breadth between bolt holes in base.	Diam. Shaft, ins.	"D." Diam. Armature ins.	"C." Height of shaft centre from base of motor.
1/12	18	2,100	1½* / 1½†	5/8 / 1	7 3/8	5½	7⅜	4⅜	2¾	¼	3⅜	5 1/16
⅙	26	2,000	1¾* / 1¾†	5/8 / 1	9¾	7½	8½	6⅞	3⅜	⅜	3 11/16	6⅛
¼	26	1,800	2½	1¼	9¾	7½	8½	6⅞	3⅜	⅜	3 11/16	6⅛
¼	65	1,500	3	2	14¾	9½	10¾	9¾	4 1/16	7/16	4¾	7½
½	100	1,350	3½	3	18¾	11	13	11½	5½	½	5¾	9
1	157	1,050	4	3½	19	13¼	15½	12¾	7	⅝	7 5/16	10½
2	290	1,050	6	3	25	15⅝	18⅜	18¾	9¼	1	8¼	11 7/16
3	300	1,000	6	4	26¼	15⅝	18⅜	18¾	9¼	1	8¼	11 7/16
5	485	1,000	7½	4½	28	18¾	21	18¾	9¾	1⅛	9¼	12¾

* Grooved. † Flat.

NOTE.—The standard incandescent motors are wound for 110, 220 and 500 volts. Each motor is tested, and the speed and voltage stamped on before shipment; but should the voltage of the circuit vary from the standard, there will be a corresponding difference in the speed of the motor. Arc motors are wound for 6.5, 9.5 and 18 ampères.



DIMENSIONS OF CROCKER-WHEELER MOTORS.

The Dimensions of Crocker-Wheeler Motors.

The space occupied by the electric motor is so much less than that required for a stationary engine of the same capacity that a great advantage is gained in favor of the motor in all locations where space is a matter of importance. As a means of comparing dimensions of steam engines which any of our readers may have in use with those of one of the standard types of electric motors, the table of dimensions and other data and the diagramatic view of the Crocker-Wheeler motors are given on this page. By reference to the table and cut it will be seen that the outside dimensions of a motor of any given capacity are readily obtainable. The floor space and weight per horse-power will always be found to be very much in favor of the electric motor as against the engine and boiler, or even the engine alone. It must, however, be remembered that in many installations the motor can be made to occupy space that is otherwise of little or no value, as in cases where it may be attached to the ceiling in an inverted position or placed upon a suitable bracket against the wall.

Electric Lighting in the Elgin Watch Factory.

The adaptability of the incandescent electric light to purposes requiring a soft, brilliant, and easily controlled light has long since been demonstrated, and in manufacturing estabiishments producing goods of a delicate and complex nature it has been found absolutely indispensable in obtaining good work from employés. This has very often been appreciated, but never in a greater degree than by the Elgin National Watch Company, at Elgin, Ill. This company authorized the installation of an electric lighting plant, which has, in the fourteen months of its existence, assumed proportions which entitle it to be classed among the largest and finest of its kind in Illinois.

The generating machinery is placed in a separate wing of the building, which is so constructed that each machine rests upon an isolated and massive foundation, thus insuring freedom from all unsteadiness and vibration. The most exquisite neatness is observable at every turn and the greatest pride is taken by the men in charge in keeping everything about the plant in the best of order. As current is supplied continuously the force works in two shifts, the day men being on duty from 7 A. M. to 6 P. M., and the right men the remaining time. At the end of every two weeks the forces are exchanged. This plan secures uniformity in hours and character of service.

Steam is furnished from the main battery of boilers, 20

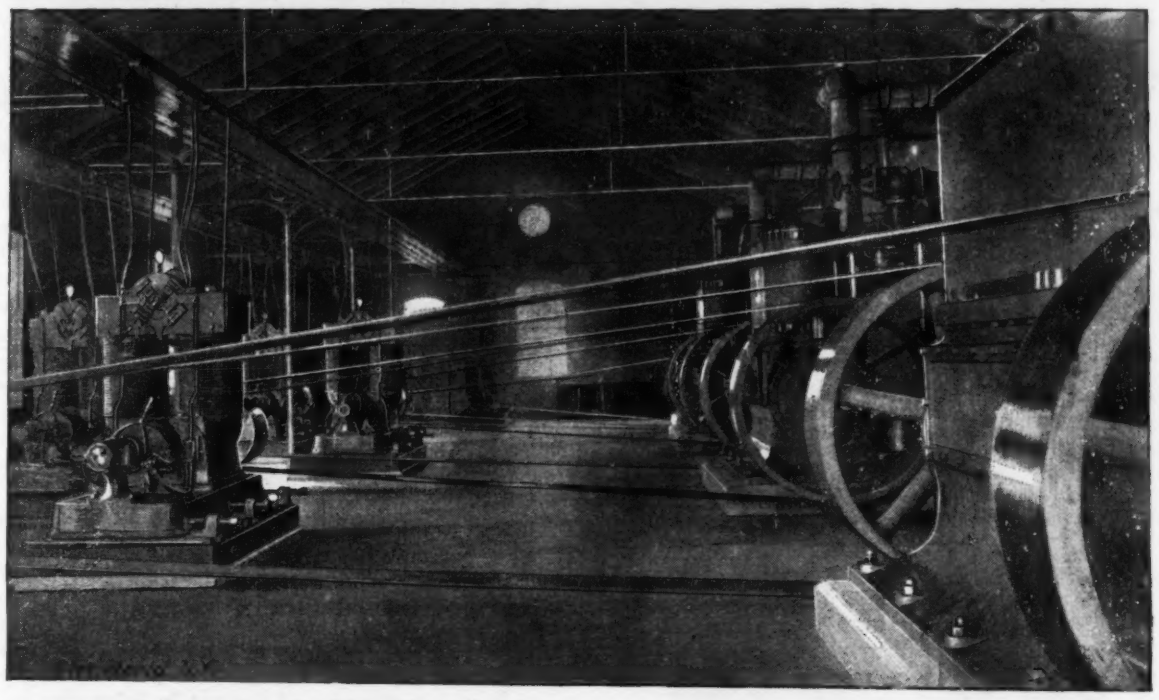


FIG. 1.—DYNAMO AND ENGINE ROOM OF THE ELGIN (ILL.) WATCH COMPANY'S PLANT.

in number, shown in Fig. 2, which were built by John Mohr & Son, of Chicago, and are fitted with oil burners. At present the consumption of oil averages one car per day. The engine equipment consists of three standard Westinghouse automatic engines, as shown in Fig. 1, developing 200 h. p. with 250 revolutions per minute, and one 75 h. p. engine of the same make and type. Each of the larger engines is belted direct, as shown in the figure, to two No. 20 Edison dynamos, the smaller engine operating two No. 8 dynamos of the same pattern. The total capacity of the plant is sufficient to supply current to 6,000 16 c. p. lamps. Munson and Schieren belts are used throughout.

It is a most interesting sight to watch the wholesale extinguishing of lights which takes place at a few minutes past six o'clock. The circuits being controlled from the switchboard, two men are required to operate the rheostats and switches.

The plant is under the direct supervision of Wm. Lawrie, chief engineer, assisted by Geo. Scoville, electrician.

Annual Report of the Federal Street and Pleasant Valley Railway Company.

The annual meeting of the stockholders of the Pleasant Valley Passenger Railway Company, of Pittsburgh, Pa., was held recently, at which the following statement of the company for the year ending Dec. 31, 1890, was presented:

EARNINGS.

Gross receipts for the year		$331,900.80
Total passengers carried during year, 6,612,913.		
EXPENDITURES.		
Pay rolls	$141,207.71	
Motor and car supplies	13,688.35	
Fuel and light	8,628.45	
Engines and boilers	2,767.69	
Dynamos	1,724.27	
Overhead system	1,713.33	
Roadway and stables	12,515.72	
General expense, taxes, bridge tolls, etc	33,268.12	
Interest on bonds	27,000.00	
		$242,513.64
Net earnings		$89,387.16
Surplus Jan. 1, 1890		21,026.70
Total		$110,413.86
Paid Dividend No. 31, July, 1890		39,000.00
Surplus Jan. 1, 1891		$71,413.86

The report of President D. F. Henry to the stockholders of the Federal Street and Pleasant Valley Passenger Railway Company contained the following statement:

"One year ago we were on the eve of replacing horse-power by electricity, to meet the requirements of our patrons, then little knowing the great work we had undertaken or the difficulties to be overcome.

"The first obstacle to our enterprise was that of public prejudice, as voiced by the daily press, against our system of overhead wires. It was claimed that the use of electricity as a motive power by overhead wires was dangerous to life and property. The fallacy of this claim could only be disproved by actual demonstration. Naturally there were many doubting Thomases.

"In addition to public prejudice we had to contend with rival companies, who sought by injunctions in the courts and in many other ways to prevent us from equipping our road in both cities. Our attorneys were equal to the emergency, and to-day I am glad to be able to state that we have no lawsuits pending of any consequence.

"We have completed the laying of about 58,000 feet, or 11 miles, of track with the improved Johnson girder rail, including the Irwin avenue, Perrysville avenue and California avenue divisions; also relaying and completing 31,000 feet, or about six miles, with tram rail, upon the California and Madison avenue divisions. We have now about 18 miles of single track.

"The large substantial fireproof power station is equipped with two Hazelton tripod boilers, of 500 h. p. each; also a battery of two horizontal tubular boilers, of 125 h. p. each; total, 1,250 h. p., with the Roney patent smokeless stokers, tanks, coal and ash conveyers, steam pumps, heaters and purifiers; an artesian water well, with steam pump; two large tanks for a water reserve in case of accident, or shutting off the city water supply; also a fire protection. The coal bins have a capacity of 1,000 tons, or 40 days' supply.

"We have three Buckeye engines, two of 400 h. p. each, and one of 200 h. p.; total, 1,000 h. p.; five Edison dynamos, of 80,000 watts each, or combined 535 electric h. p.; three Thomson-Houston dynamos, of 60,000 watts each, or combined 240 electric h. p.; making a total of 775 electric h. p.; all connected with main shaft, with idle pulleys thereon to attach two additional dynamos of 80,000 watts each, which would balance the engine capacity. We would still have in reserve 250 h. p. boiler capacity.

"We shall need and have contracted for a 250 h. p. engine, also dynamo of equal capacity. We shall then have ample power, with a reserve both in steam and electricity, for all requirements of the near future. In our power station there still remains room enough for considerable more power for future extensions.

"We have remodeled our buildings into repair shops, with suitable examining pits; machine shops, with engine, elevator, lathes, drill presses, planers, milling and boring machines, emery and grinding wheels, and blacksmith forges; electric shops, with lathes, dryers, and insulating apparatus for the building of new car motors, and station equipments and their repair; a carpenter or car shop, with engine, planers, lathes, saws, boring machines, for building new or altering cars suitable for electric service; a complete stable outfit, with first-class horses, harness, wagons for hauling coal and other supplies, track sweeper, water carts, etc.

"We have also purchased a large lot of ground at the end of the main line, and erected a commodious car house, covering the entire space 140 by 145 feet, having capacity for 75 cars. This will afford ample storage room for all cars on the main line, as well as all not in daily use on all the other divisions.

"We have also purchased property and built a car house on the Perrysville avenue division, at Charles street. This will afford capacity for all the cars on this division. We have also a car house on the Madison avenue division for all cars in use there. We have also a car house and waiting room on the California avenue branch. This will without doubt become the most important branch of our line.

"Upon the completion of the branches we will have one of the most extensive and valuable street railway properties in the country, as well as one of the most complete electric roads in all its details in the world, and that, too, with a comparatively small issue of stock and bonds.

"We have now 50 motor cars, 25 trail cars, six snow plows, five salt cars, one snow sweeper, a stone crusher, engine and boiler, enabling us to ballast our suburban roads at the least possible expense.

"In regard to the cost of operation of our system, number of passengers carried, etc., I submit the following, based upon the business of the past six months: Passengers carried, 3,370,531; for the year past, 6,612,913; receipts, six months, $168,526.55; for the year past, $331,900.80. Mileage, 31 cars, averaging each 108 miles per day; total daily average, 3,348 miles; six months, 611,800 miles; in 12 months 1,223 miles, or equal to fifty times around the earth. Cost per mile:

Conductors and motormen	per mile,	6.80 cts.
Motor and electric repairs	"	1.68 "
Mechanical repairs	"	1.14 "
Motive power	"	1.54 "
Overhead system	"	0.45 "
Maintenance of way	"	1.08 "
General expense	"	0.88 "
Stables	"	0.46 "
Officers and salaries	"	0.84 "
Interests	"	2.71 "
Tolls	"	0.25 "
General labor	"	2.43 "
Total		20.26 cts.

as total cost per mile of operating expense, fixed charges, salaries and interest; as against receipts per car mile as above of 27.55 cents; showing net earnings per mile of 7.29 cents.

"Separating the above into strictly operating expense and fixed charges, we have operating expense, 12.74 cents per car mile; and in comparing the same with the cost of operating the horse line, which was 10 cents per car mile, we must remember that we then paid but one man on a car, where we now pay four, or .03 cents per mile against 6.80 cents now. This increased cost per mile for conductors and motormen is a necessary adjunct of rapid transit, and is not peculiar to the system. Allowing for this, we have a difference of 1.04 cents per car mile in favor of electricity as against animal power.

"I call attention to the fact that we have one of the most difficult roads to operate in existence, with streets having over one hundred curves, many of which have a short radius, and with heavy grades, leaving but little straight and level roadway. We have also six steam and six cable railway crossings. It would be impossible to have rapid transit on our road, except by the use of electricity as a motive power. This enables us to control our car with ease and safety.

"As to the relative merits of the various electric systems in existence at the present time, I am convinced from practical knowledge and careful investigation that we have made no mistake in our selection; and all things considered, with a few minor improvements we have as good a system as any in operation to-day.

"We are constantly making improvements in our motors and in the care of them, and within a year can

FIG. 2.—BOILER ROOM OF THE ELGIN (ILL.) WATCH FACTORY.

reasonably expect to be comparatively free from the difficulties which we have to contend with at present in the use of electricity.

"In the twelve months that the road has been in operation, the total time lost was but twenty hours, three of which was on account of the shutting off of the water supply to the boilers, and three hours from engine and line troubles. The other twelve hours was caused by two of the most severe snow storms experienced for many years. These storms commenced on the 16th and 25th days of December. The first snow fall was sixteen inches and the last ten inches. With our narrow streets and sharp curves, our sweeper piled the snow on either side of the track to the height of from four to six feet; consequently the snow fell back upon the track, thereby destroying our traction and derailing the cars, but not, as has been erroneously reported, interfering with the electric contact. Steam, cable, or even horse cars under the same circumstances would have been compelled, as we were. to resort to shovels. Our wires, too, during this storm gave no trouble; but we were somewhat annoyed by the falling of telegraph wires upon ours, which were easily and quickly removed.

"In conclusion, would call your attention to the fact that we have been in operation nearly a year, with our system so entirely new in this section, and have aggregated so many miles and carried so many millions of passengers, it certainly affords me great pleasure in being able to state that not one single person has received the slightest injury *while on board our cars*, nor has any person or animal been injured by our wires upon the streets. I believe this record to be unsurpassed by any company handling a like number of passengers, with either steam, electric, cable or horse power."

The Construction and Use of Electrical Testing Apparatus.

BY CHARLES P. FREY, CHIEF ELECTRICIAN GREELEY ELECTRICAL LABORATORY.

X.

Tangent Galvanometers.—If a magnet which is suspended or mounted in any manner permitting free horizontal rotation is moved out of its normal position by any mechanical, electrical or other force which will not permanently destroy its magnetic properties, it will be re-established in its original position as soon as the divertive influence ceases and the effect of any mechanical jar has subsided.

Fig. 41.—Tangent Galvanometer, Western Union Standard.

If a magnetized needle be mounted on a pivot or suspended by means of a fibre, and another magnet be brought near it, mutual attraction of dissimilar and repulsion of similar poles ensues, and the normal position of the needle will be altered while the magnet remains sufficiently near to make its influence apparent.

A constant electric current passing through a conductor invests the conductor wtih magnetic properties for the time being. For instance, if a current is sent through a spiral of wire, the spiral will have a north and a south pole at the respective ends of the spiral. (As is well known, the magnetic "field" will be increased or concentrated by inserting an iron core; but this fact has no bearing on the subject.) The conductor alone, though not necessarily of iron or steel, will in fact become a temporary magnet. This being the case, if we arrange a conductor so as to encircle a movable magnet one or more times, then at a fixed distance the influence on the needle of a current passing through the conductor will be proportionate to the strength of the current. This is the principle of a tangent galvanometer.

For practical purposes the ring on these galvanometers, through which the current passes, frequently consists of a thick copper wire, bent in the form of a circle of practically zero resistance (see Fig. 40). The two ends of the ring do not of course touch each other, but are fastened to terminals in the form of tubes, projecting at right angles to the plane of the ring, one tube being outside the other and insulated from it. This ring is mounted on a brass column which rotates on a suitable base provided with leveling screws.

A small magnetized needle is placed in the centre, moving in a graduated circle. As the needle is small compared with the diameter of the circle, it may be assumed that the needle always moves in a magnetic field of uniform strength. This being the case, the strength of the current

Fig. 39.—1-8 Metre Ring, Tangent Galvanometer.

circulating in the ring is practically proportional to the tangent of the angle of deflection of the needle. The angle of deflection is reckoned from the plane of the ring, which must be placed parallel to the magnetic meridian.

As it would be difficult to read off the angular deflection of the needle from the needle itself, a long aluminium pointer is attached at right angles to it, which moves over

Fig. 42.—Helmholtz Gaugain Galvanometer.

a graduated scale. This scale is graduated in one-half degrees.

Now, as the strength of currents producing certain deflections is proportional to the tangents of the degrees of deflection, we must, before working out a formula which has reference to the strengths of the currents, reduce the degrees to tangents from a table of tangents.

Western Union Standard Tangent Galvanometer.—This instrument (Fig. 41), once extensively used for telegraph

Fig. 40.—Half Metre Ring, Tangent Galvanometer.

line tests, but now to a certain extent superseded by more modern apparatus, consists of a tangent galvanometer provided with five coils. The first of these is a stout copper band of inappreciable resistance; the others are of different sized copper wires carefully insulated. Five terminals are provided, the plug holes of which are marked respectively 0, 1, 10, 50 and 200. The ends of the coils are so arranged that the plug inserted at the terminal marked 200 puts in circuit 200 ohms of the galvanometer coils; at the terminal marked 50, the 50-ohm galvanometer coil, and so on, till at the zero terminal only the copper band is in circuit.

Fixed to the needle, which is balanced on jewel and point, is an aluminium pointer at right angles extending across a five-inch dial immediately beneath. The circumference of the dial is divided on one side into divisions proportioned to tangents of the degrees. The strength of any current passing through the coils of this instrument being directly proportional to the tangent of the angle of deflection, it is at once shown by the reading on the tangent side of the dial. The other side is graduated to ordinary degrees of arc. In the base of this galvanometer is a set of resistance coils of the respective values of 10, 500 and 5,000 ohms.

To obtain the most accurate results with a tangent galvanometer, it is best to so adjust our resistances or battery power that we will obtain deflections ranging between 30 degrees and 50 degrees, which range should be sufficient for most measurements. Deflections above or below these values should be avoided if possible. The wires carrying the current to the instrument should be well insulated and twisted together in order that all magnetic action of the current in the wires may be neutralized.

Helmholtz Gaugain Galvanometer.—A source of slight inaccuracy in all forms of single ring galvanometers, due to the weakening of the action of the current on the needle—the farther the needle is away from the plane of the coil—is obviated in this instrument (see Fig. 42), which has two rings, each wound with two independent parallel coils. These coils are placed with their planes vertical and parallel to each other, the distance between the centres being equal to the radius of either coil. The needle is suspended by means of a fibre at the middle point of the axis of both coils. With this arrangement it can be shown mathematically that the magnetic field surrounding the magnet is very nearly uniform, provided that the needle is very short in comparison to the radius of the coils. Hence the current strength is very nearly proportional to the tangent of the angle of deflection.

Sine and Tangent Galvanometer Combined.—The essential difference between a sine and a tangent galvanometer is that in the sine galvanometer the wire coil can be rotated about a vertical axis and so made to follow the needle during its deflection. The angle of rotation is observed by a horizontal scale and vernier. In use the instrument is first placed with the plane of its coil parallel to the magnetic meridian, the axis of the needle being then in the plane of the coil. When the current is sent through the coil the needle is deflected, and then the coil is slowly rotated till its plane again coincides with the axis of the needle. The angle of rotation is then observed. The current is proportional to the sine of the angle of deflection. (See Fig. 43.)

The advantage of the sine galvanometer is that the law

Fig. 43.—Sine and Tangent Galvanometer Combined.

of sines is independent of the size and form of needle and pointer; the disadvantages are its troublesome adjustment and the doubled sources of error in reading. The limit of difference of current strengths which can be compared by this instrument is the same as that of the tangent galvanometer if the coils are of large diameter, and wider if the coils are of small diameter.

The Edison Company's Arc Plant at Long Island City.

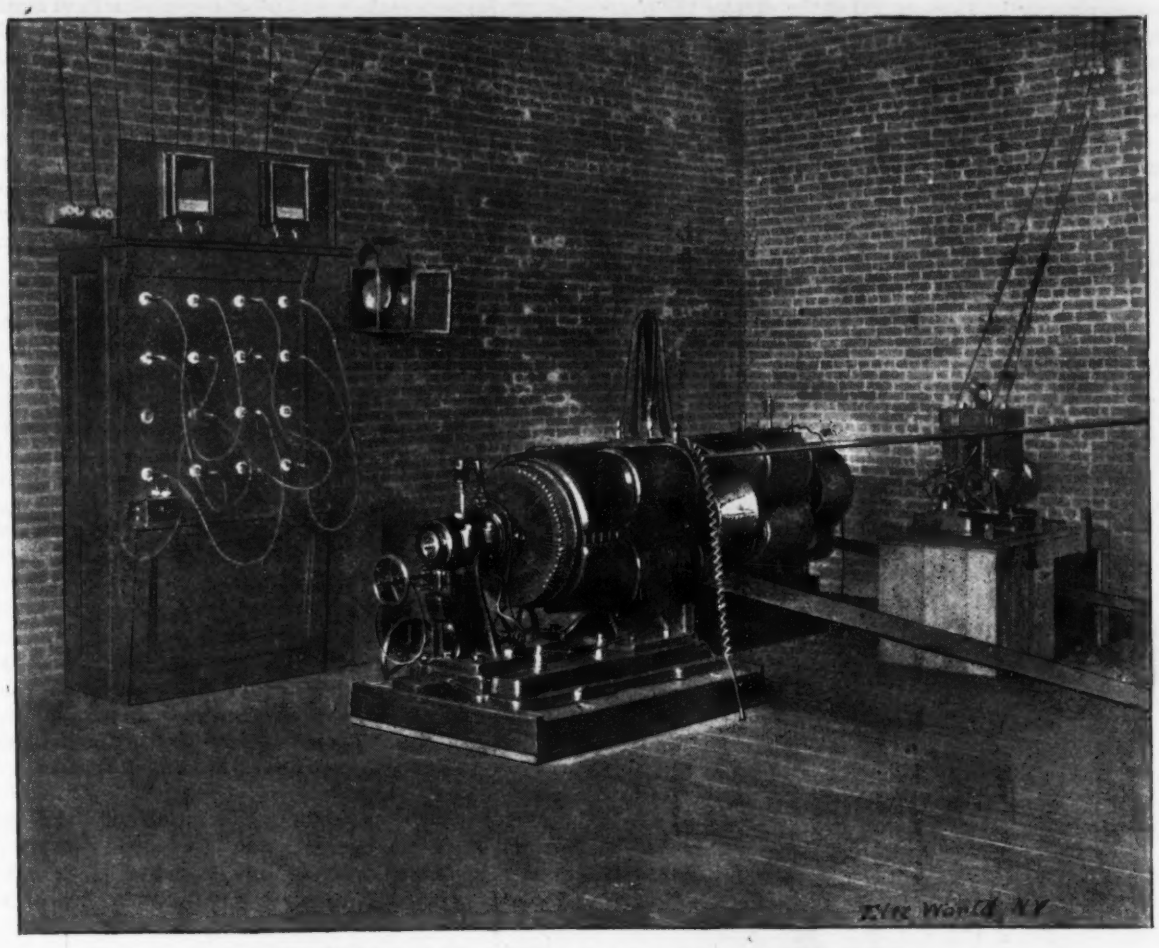
The Edison General Electric Company, so long unrepresented in arc lighting, has at last entered this part of the field of electric illumination, and in Long Island City, at the yards of the Long Island Railroad Company, can be seen the first Edison arc installation.

The dynamos are of the modified Sperry type, for which machines is claimed a high efficiency as a result of the form of the pole pieces and their relation to the Gramme ring armature employed; the distinctive feature (as was described in The Electrical World) being the use of interior as well as exterior "lips" upon the pole pieces, between which runs the wound rim of the Gramme armature. The accompanying illustration shows the two 40-light dynamos of the L. I. R. R. plant, with the arc switchboard, and the small 50-light incandescent Edison dynamo, used for supplying a few office lamps.

The machines are run from a 80 h. p. Westinghouse "Standard" engine, which was furnished as part of the complete power and heating plant by Messrs. Manning, Maxwell & Moore, whose boilers are used for supplying the engine and for heating the coaches of the railroad company. The boilers are of the usual horizontal tubular type of Manning, Maxwell & Moore, and are each of 80 h. p.

The station is a compact brick building of one story, comprising the boiler and dynamo room, and has a central location in the yards of the L. I. R. R. The circuits lead from a distributing tower on the roof, and at present the machines are run to almost their full capacity, supplying lights for the illumination of railroad yards which have had heretofore many dark corners.

The Sperry "triple carbon" arc lamp is used, and the novel arrangement of the carbon gives a long life and an efficient radiation of light.



EDISON ARC LIGHT PLANT AT LONG ISLAND CITY.

Lighting of the Metropolitan Opera House at St. Paul.

BY CLARENCE M. TOLMAN.

This opera house has but just opened its doors, the Bostonians dedicating it with English opera. Through the kindness of Mr. L. N. Scott, manager, THE ELECTRICAL WORLD is able to lay before its readers an illustrated account of the isolated plant in use and to show the manner in which incandescent lights have aided in securing decorative effects of the greatest taste and elegance. It is but fair to say that for excellence of design, adaptability to the purposes in view and elegance of finish the theatre has perhaps no superior in the country.

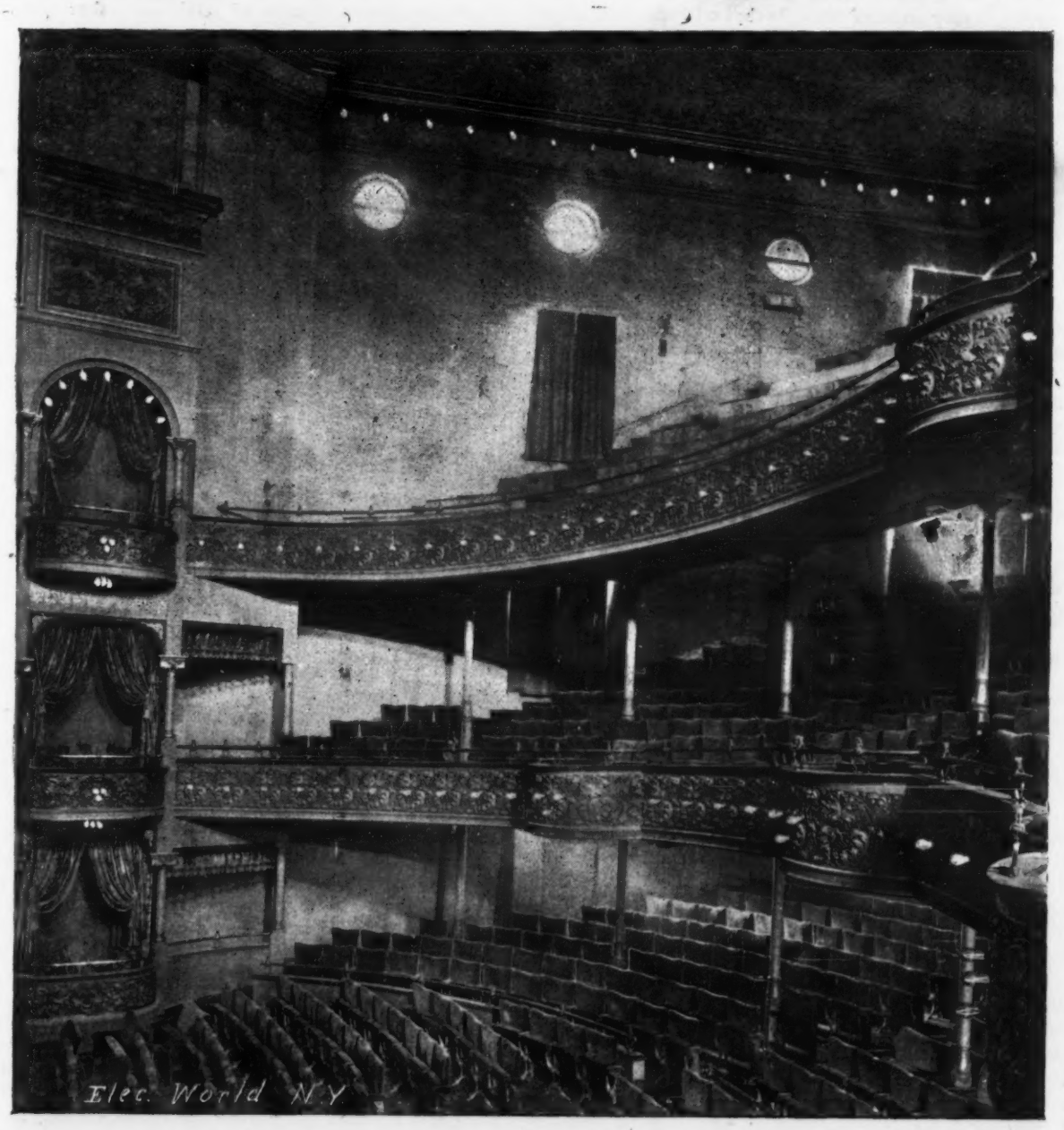
The power plant is placed in the basement, beneath the front entrance. The only wood in the engine or boiler rooms is that used in the switchboard and the framing of the glass partition between the two rooms—in fact, the entire building is as nearly fireproof as a carefully worked out design can make it. There are two Babcock and Wilcox boilers of 140 h. p. capacity each. The fire-box of each boiler is provided with two doors, side by side and a short distance apart, allowing a much more even distribution of fuel to be had when feeding. The coal is dumped directly from the street to a vault beneath the pavement, so situated that little handling is required to bring it to the fire-box doors. A partition of brick and glass separates the boiler from the engine room. This latter is 30 feet by 22 in size. It might have been profitably added to, in the designing, especially in length, thus securing longer belts and additional space around the engines and dynamos. Power is furnished by two 13 × 12 Ideal engines, giving 95 h. p. each at 295 revolutions per minute and 40.5 pounds mean effective pressure. The engines exhaust into a cylindrical combined grease extractor and feed water heater. Then the exhaust steam passes through coils, thus heating the surrounding air, which is blown into the auditorium, forming part of the heating system. Lastly the exhaust goes over the house, through the heating pipes, at low pressure. The condensation and drip return to a tank beneath the grease extractor and are thence fed to the boilers by a Worthington pump. Provision is also made to admit, by a reducing valve, steam at any pressure to the air heating coils or to the main warming system. The engines were furnished and installed by Mr. J. G. Robertson, who is the agent for the Ideal engine in St. Paul.

The dynamos consist at present of three Thomson-Houston class D 30 motor type generators, compound wound for automatic regulation, belted directly to the engines by light double belts furnished by the W. S. Nott Company, of Minneapolis. Two dynamos are belted to one engine and the third to the other engine, leaving opportunity for a fourth dynamo if desired. One gene rator, owing to the limited space at hand, is placed with the centre of its armature shaft at a distance of 10 feet from the centre of the engine shaft. With an engine pulley 60 inches in diameter and a dynamo pulley of 14 inches, and the consequent short arc of contact, a very tight belt must be kept in order to transmit 40 h. p., and varying loads. The other two dynamos are placed so as to give 14 feet between centres. The generators give 240 ampères each at 110 volts potential. The current of 720 ampères is taken from the machines to a switchboard at the side of the engine room, on which are placed the switches for handling the current from each machine separately, also the volt and ampère meters and the field rheostats. From the switchboard all the current, except that used in the offices at the front at the building, is taken by the mains to the distributing switchboard on the right side of the stage. Thence it is supplied to the stage and auditorium, the foyer and halls. The feeders, supplying various portions of the theatre, as the front of the balcony, or the sounding board, or the proscenium boxes, and controlled entirely from the stage switchboard, are run to junction boxes, conveniently located for inspection and renewal of fuses, and are there sub-divided into groups of six lights each.

The wires of each six-light group are protected by a double pole fuse box. The entire system of wiring was calculated to allow a loss of not more than five per cent. between dynamos and lamps. The wire used is Grimshaw throughout, from 0000 to 16. To give an idea of the work done in a theatre installation, it may be said that over 36,000 feet of wire were run in placing the 1,300 lights. The stage and scenery are shown to advantage by 50 footlights of 16 c. p. each, and by five rows of border lights containing 40 lights each. These 40 lamps form two circuits of 20 lamps each, placed alternately with separate fuses. The border lights are placed in reflectors and may be lowered to within three feet of the stage or raised to the top of the flies, carrying their feeding wires with them. The border lights, the footlights and the entire system of auditorium lights are completely under control as to brilliancy and effect by 16 Thomson-Houston special rheostats, each having 15 loops or variations. These rheostats are of four types, "19," "30," "31" and "32," according to the size of the groups to be handled.

The effect of the three lamps on the front of each box, except the lower row, amid the solid plaster decoration of lion's mane tint, is most pleasing to the eye. The illustration shows the fronts of the two balconies. The effect of the two rows of lights is very brilliant. The curve of the lower balcony is broken by three swells, each with its group of lamps. The tint of the ceiling is old ivory, which diffuses the light well. The central lamps, two of them, are of 50 c. p.

The installation of this plant was performed by the N. W. Thomson-Houston Electric Company, of St. Paul, by Mr. R. D. Harrison, acting under the supervision of Mr. W. J. Bonwell, the company's superintendent of construction of the lighting department. Messrs. Ames, Wright & Co., the St. Paul agents of the Western Electric Company, have thoroughly equipped the building with the necessary speaking tubes and electric bells. The architect is Mr. C. A. Reed, of St. Paul, and to his unremitting attention, even in the matter of small details, is due the completeness of the edifice.



LIGHTING ARRANGEMENTS OF THE METROPOLITAN OPERA HOUSE AT ST. PAUL, MINN.

Electricity in Transitu: from Plenum to Vacuum.*

BY PROF. WILLIAM CROOKES, F. R. S.

LOOSE AND ERRATIC MOLECULES.

In the brief time left to me this evening I cannot touch upon the mass of experiments made to render this result clear, so I will at once show you a piece of apparatus that clearly illustrates the cause of phosphorescence at the positive pole. A drawing of this tube is shown at Fig. 26, but let me first explain the effect I expect to obtain, and then endeavor to show the actual experiment.

A C B is a U-shaped tube with terminals, *A* and *B*, at each end; *D* and *E* are two mica screens covered with a phosphorescent powder, having at *F* and *G* other screens with a small slit in front, so as to allow only a narrow beam of charged molecules to pass through. At first the tube is exhausted to a pressure of 0.076 millimetre, or 100 M, and you see how sharp and slightly divergent is the luminous image on screen *D*, while not a trace of phosphorescence is to be seen on the screen *E* in the other limb of the tube. Now I push the exhaustion to the highest point short of non-conduction. (0.000076 millimetre, or 0.1 M), and the phenomena change. The initial line of light on *D* becomes wider and unsteady, while at the gate *C* a decided phosphorescence is observable entering the second screen *E*. This luminosity diverges to a considerable extent, much more than did the stream of charged molecules observed in the first limb of the tube at the lower exhaustion. This is only to be expected, inasmuch as those sparse molecules which have run the gauntlet of the crowd and have been hunted and buffeted round the corner will have little or no lateral support, but wander to the farthest part of the tube, and altogether behave differently than the orderly procession of molecules at more moderate exhaustion.

THE RESISTANCE OF HIGH VACUA.

I must only lightly touch this phenomenon to-night; it is a subject of deep interest, and to which I have lately devoted much time. Shortly I hope to publish a full account of results recently obtained.

The passage of an induction current at a high vacuum through a tube depends much upon the material of the tube or the substance inclosed within it. Given the same degree of exhaustion, and the same distance between the terminals inside the tube, the E. M. F. necessary to force the current through may vary from 3,000 to 20,000 volts, according to the particular material used.

Here is a very striking example that will serve to illustrate this phenomenon. Fig. 27 is a double tube joined by a narrow open channel and therefore in the same state of exhaustion throughout ($P = 0.02$ millimetre, or 26 M). Each tube is furnished with a pair of poles, *A B* and *A' B'*. One tube contains the phosphorescent earth yttria, the other contains finely divided carbon. I first connect the yttria tube, *C*, to the coil, and place in parallel circuit with it a spark gauge. To begin with, this gauge is set to a gap of 1 millimetre. (An E. M. F. of 920 volts is necessary to strike across 1 millimetre of air; therefore the difference of potential at the terminals inside the yttria tube is 920 volts, and this you perceive is not sufficient to force the current through the tube.) I now gradually open the gauge until the potential of the inner terminals has risen to a point

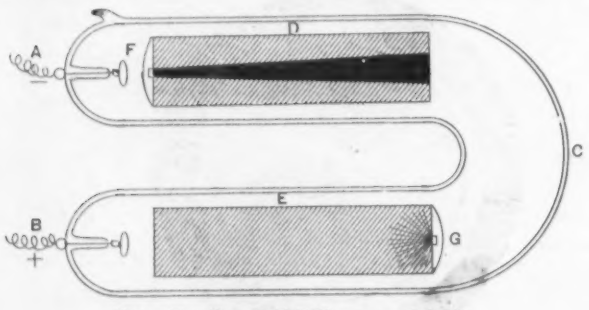


FIG. 26.—P = 0.000076 MM. = 0.1 M.

high enough to allow the spark to pass through the tube, making the yttria phosphorescent.

The gap is at 7 millimetres equal to an E. M. F. of 6,440 volts. I next attach the coil wires to the tube *D*, containing the carbon, and the exhaustion in the tubes being the same as before, I repeat the experiment; you now see that the gap has to be opened to 30 millimetres, equivalent to an E. M. F. of 27,600 volts, before the current will pass through the tube. The fact of whether the vacuum tube contains yttria or carbon makes a difference of 21,160 volts in the E. M. F. required to cause a discharge between the terminals.

One other experiment I would like to show in further illustration of this resistance. The idea suggested itself that possibly differences in the material or conductivity of the particular bulbs might influence the results you have just seen. Here (Fig. 28) is a long, cylindrical tube of phosphorescent Bohemian glass containing a pair of terminals, *A B*; it also contains a shorter cylinder of glass, *C C*, brightly silvered inside. The internal pressure is 0.00068 millimetre, or 0.9 M. The silver cylinder is now at one end of the tube out of the way of the terminals, which, therefore, have phosphorescent glass around them. I turn on the coil and find that the E. M. F. necessary to force the current through, now that the terminals

* Presidential address before the Institution of Electrical Engineers, London; concluded from THE ELECTRICAL WORLD, Feb. 14, 1891.

are in a phosphorescent chamber, is 1,380 volts. I slide the cylinder down to the end of the tube so as to inclose the terminals in a metallic silver chamber, and you see the E. M. F. necessary to pass the current rises to 6,440 volts. Metallic silver does not phosphoresce, while Bohemian glass phosphoresces very well. It appears that the greater the phosphorescing power of the substance surrounding the poles, so much the easier does the induction spark pass. Surround the poles with Bohemian glass or yttria—two phosphorescent non-conductors of electricity—and the induction spark passes easily; immediately I surround the terminals with a non-phosphorescent conductor the current refuses to pass.

WHAT OCCASIONS PHOSPHORESCENCE?

I should like to interest you in a question that has exercised my mind for some time past. What is it that occasions the phosphoresence of yttria and other bodies *in vacuo* under molecular bombardment?

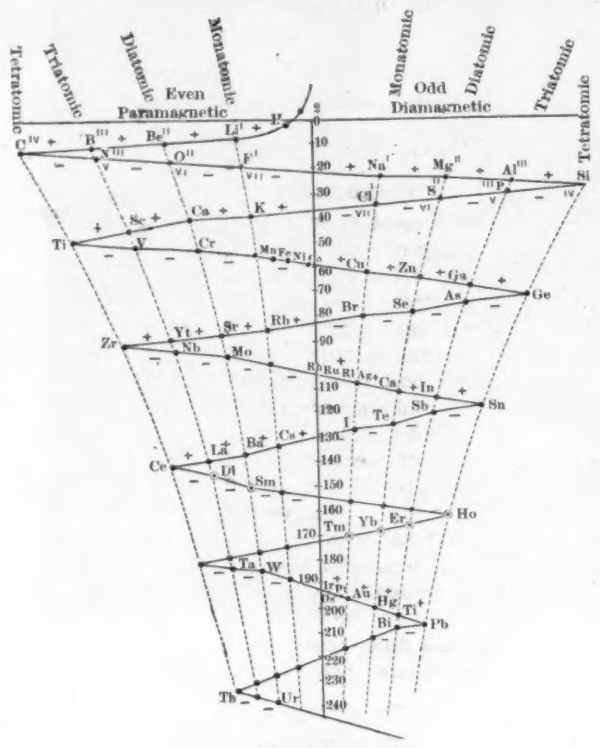


FIG. 30.

So far I have found this phosphorescence to be an attribute of non-conductors only. We know that in the act of phosphorescence the molecules of yttria are in a state of intense vibration. Each molecule may be viewed as the radiating centre of the entire bundle of rays, which, when decomposed by the prism, displays a discontinuous spectrum. We may also suppose that the residual atoms of gas charged with negative electricity give off their electricity on coming in collision with a phosphorescent body and on their return take up a fresh charge.

THE ELECTROLYSIS HYPOTHESIS.

There is a certain amount of evidence in favor of an electrolytic hypothesis of the passage of electricity through rarefied gases. This has been ably advocated by Prof. Schuster in the Bakerian Lecture before the Royal Society, March 20, 1890.*

A molecule of hydrogen gas, for instance, may be made up of one group of atoms of hydrogen having an equivalent of negative electricity inherent in it and one group of atoms having an equivalent of positive electricity bound up with it. These atoms are also charged with *additional* equivalents of positive or negative electricity, which they carry about as a ship carries its cargo. We are not concerned with the inherent electricity—of which we are ignorant—but with the extra or "cargo" charge. Let us imagine a molecule of hydrogen near the face of the negative pole in a vacuum tube. I turn on the current and the atoms of the hydrogen molecule are dragged apart. The positive atom is attracted to the negative pole, where the violence of impact, or the discharge of electricity, renders it apparent with evolution of light. The internal luminous layer, which is closely adjacent to the negative electrode, is due, therefore, to the positive atoms rushing to the negative pole, and not like the glow round the edge of the dark space, to the negative atoms projected from it. The negative atom, on the other hand, is driven violently from the negative pole, in virtue of the mutual repulsion existing between any two bodies similarly electrified, with a velocity varying with the intensity of the electrification and the degree of the vacuum; the more perfect the vacuum the greater the velocity, the atoms flying outward in straight lines until they meet with an obstacle. Such an obstacle may be a procession of positively charged atoms from the positive pole; in this case the two kinds of atoms mutually discharge each other's cargoes with a display of light. This phenomenon occurs at the margin of the dark space when the vacuum is only moderate. Or the obstacle may be produced by the vacuum being so high that the atoms of gas present are too few to form a continuous procession. (*Why* a high vacuum should be non-conductive does not clearly appear, but the fact itself is beyond doubt; it is probably connected with the inability of electrified atoms to leave the poles.) Or again, the obstacle may be a phosphorescent body, like yttria. In this case the negatively charged atoms deliver up their charge of electricity to the yttria, which is so constituted—perhaps after the manner of a Hertz resonator—that its atoms charge and discharge, vibrating about 550 billion times in a second, and producing waves in the ether of the length, approximately, of 5.75 of ten-millionths of a millimetre, and occasioning in the eye the effect of citron light.

* *Roy. Soc. Proc.*, XLVII., 526.

We are not under the necessity of supposing that this number of hydrogen atoms are driven against the yttria in the second, although even at a high vacuum there are quite enough atoms left in the bulb to keep up such a supply. All that is needed is that a succession of shocks, not necessarily rhythmical, may strike the yttria at frequencies which will set up such a number of vibrations, just as a series of slow impacts on a gong causes it to emit sound waves of much greater frequency.

In a low vacuum only very few atoms can run the gauntlet among the crowd of inrushing atoms: and those few which succeed in reaching the yttria arrive with much reduced velocity, and so faint is the phosphorescence they set up that it is completely obscured* by the brighter phosphorescence of the residual gas. As the vacuum becomes higher, more and more atoms find their way across, and, their speed being at the same time accelerated, the phosphorescence becomes intensified.

At a good vacuum most of the atoms hit the yttria, their velocity is increased, and the rythmical excitation reaches its maximum.

THE DARK SPACE IN MERCURY VAPOR.

In applying the electrolytic hypothesis, I have used for illustration's sake the gaseous residue of hydrogen, which is known as a diatomic gas. I have found, however, the phenomena of the dark space, etc., to occur in the vapor of mercury, which is a monatomic gas. This important result induced me to patiently investigate this subject, and the result of one experiment is before you (Fig. 29). The tube is furnished with aluminium terminals, and is so arranged that the induction spark can be kept passing during exhaustion to drive off occluded gases. When at the highest attainable vacuum, the tube is filled with pure mercury by simply raising a reservoir. On applying heat the entire contents of the tube are boiled away and pass down the fall tubes of the pump, exhaustion going on at the same time. When the whole of the mercury has thus been boiled away *in vacuo*, except a little condensed at the upper part of the tube, the results on passing the spark are as follows: When the tube is cold the induction current refuses to pass; on gently heating with a gas-burner the current passes and the dark space is distinctly visible. Continuing the heat so as to volatilize the drops of mercury condensed on the sides, the whole tube becomes filled with a green phosphorescent light, the dark space gets smaller and smaller, and ultimately the negative pole become covered with a luminous glow. On allowing the tube to cool the same phenomena ensue in inverse order. The luminous halo expands, showing the dark space between it and the pole, and this dark space gradually grows larger as the tube becomes cooler. The mercury again condenses on the side of the tube, the green phosphorescence grows paler and paler, until at last the induction spark from the large coil refuses to pass.

At first sight this result appears fatal to the electrolytic hypothesis, for if the molecule of mercury contains only

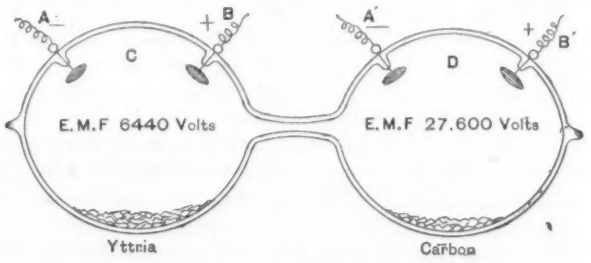


FIG. 27.—P = 0.02 MM. = 26.0 M.

one atom, how can we talk of its separation into positive and negative atoms by the electric stress? It must be remembered, however, that we are as yet ignorant of the absolute mass of the atom of any element. All that can be said is that a molecule of free hydrogen becomes halved in combining chemically with certain other elements, while a molecule of free mercury does not suffer division on yielding any known compound of mercury; the physical atoms in the one behave as two separate groups, and those in the other as one undivided group. It has been agreed by chemists, for simplicity's sake and for facilitating chemical calculations, to reduce the units to the lowest term consistent with the avoidance of fractions; we therefore say that the atoms in a molecule of free hydrogen act in chemistry as two separate groups, each of a minimum relative weight of I, while those in a molecule of free mercury act as one undivided group of the relative weight 200. But to what number of atoms the I and 200 correspond respectively no chemist knows.

To show how intimately chemistry and electricity interlock, I may here remark that one of the latest theories in chemistry renders such a division of the molecule into groups of electro-positive and electro-negative atoms necessary for a consistent explanation of the genesis of the elements. This is so important that I may be excused for

* This faint phosphorescence at a low vacuum can be rendered visible by the electrical phosphoroscope described in my lecture at the Royal Institution in 1887.

digressing a little into this development of theoretical chemistry.

GENESIS OF THE ELEMENTS.

It is now generally acknowledged that there are several ranks in the elemental hierarchy, and that, beside the well-defined groups of chemical elements, there are underlying sub-groups. To these sub-groups has been given the name of meta-elements. The original genesis of atoms assumes the action of two forms of energy working in time and space—one operating uniformly in accordance with a continuous fall of temperature, and the other having periodic cycles of ebb and swell, and intimately connected with the energy of electricity (Fig. 30). The centre of this creative force in its journey through space scattered seeds or sub-atoms that ultimately coalesced into the groupings known as chemical elements. The law which governs

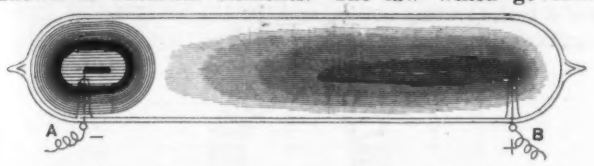


FIG. 28.—SILVER CYLINDER OFF POLES, E.M.F. = 1,380 VOLTS. SILVER CYLINDER ROUND POLES, E.M.F. = 6,440 VOLTS.

the motions of multitudes of men and women in a busy thoroughfare I have applied to the atoms of gas in a vacuum tube. At this genetic stage the new-born particles vibrating in all directions and with all velocities, the faster moving ones would still overtake the laggards, the slower would obstruct the quicker, and we should have groups formed in different parts of space. The constituents of each group, whose form of energy governing atomic weight was not in accord with the mean rate of the bulk of the components of that group, would work to the outside and be thrown off to find other groups with which they were more in harmony. In time a condition of stability would be established, and we should have our present series of chemical elements, each with a definite atomic weight—definite on account of its being the average weight of an enormous number of sub-atoms or meta-elements, each very near to the mean. The atomic weight of mercury, for instance, is called 200, but the atom of mercury, as we know it, is assumed to be made up of an enormous number of sub-atoms, each of which may vary slightly round the mean number 200 as a centre.

We are sometimes asked why, if the elements have been evolved, we never see one of them transformed, or in process of transformation into another? The question is as futile as the cavil that in the organic world we never see a horse metamorphosed into a cow. Before copper, *e. g.*, can be transmuted into gold it would have to be carried back to a simpler and more primitive state of matter, and then, so to speak, shunted on the track which leads to gold.

This atomic scheme postulates a to-and-fro motion of a form of energy governing the electrical state of the atom. It is found that those elements generated as they approach the central position are electro-positive, and those on the retreat from this position are electro-negative. Moreover, the degree of positiveness or negativeness depends on the distance of the element from the central line; hence, calling the atom in the mean position electrically neutral, those sub-atoms which are on one side of the mean will be charged with positive electricity, and those on the other side of the mean position will be charged with negative electricity, the whole atom being neutral.

This is not a mere hypothesis, but may take the rank of a theory. It has been experimentally verified as far as possible with so baffling an enigma. Long-continued research

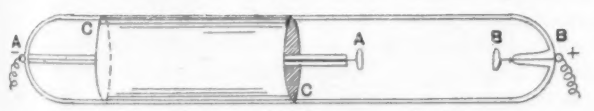


FIG. 29.—P = 0.00068 MM. = 0.9 M.

in the laboratory has shown that in matter which has responded to every test of an element there are minute shades of difference which have admitted of selection and resolution into meta-elements, having exactly the properties required by theory. The earth yttria, which has been of such value in these electrical researches as a test of negatively excited atoms, is of no less interest in chemistry, having been the first body in which the existence of this sub-group of meta-elements was demonstrated.

CONCLUSION.

I frankly admit I have by no means exhausted the subject which daily and nightly fills my thoughts. I have ardently sought for facts on which to base my theory. I have struggled with problems which must be conquered before we can arrive at exact conclusions—conclusions which, so far as inorganic nature is concerned, can only be reached by the harmonious interfusion—not confusion—of our present twin sciences, electricity and chemistry. Of this interfusion I have just endeavored to give you a foretaste. In elaborating the higher physics the study of electrical phenomena must take a large, perhaps the largest, share. We have invaded regions once unknown, but a formidable amount of hard work remains to be completed. As we proceed we may look to electricity not only to aid, as it already does, our sense of hearing, but to sharpen and develop other powers of perception. Science has emerged from its childish days. It has shed many delusions and impostures. It has discarded magic, alchemy and astrology. And certain pseudo-applications of electricity, with which the present institution is little concerned, in their turn will pass into oblivion. There is no occasion to be disheartened at the apparent slow pace of elemental discovery. The desponding declare that if Roger Bacon could revisit "the glimpses of the moon" he would shake his head to think we have got no further, that we are still in a haze as to the evolution of atoms. As for myself, I hold the firm conviction that unflagging research will be rewarded by an insight into natural mysteries such as now can scarcely be conceived. Difficulties, said a keen old statesman, are things to be overcome, and to my thinking science should disdain the notion of finality. There is no stopping half way, and we are resistlessly driven to ceaseless inquiry by the spirit "that impels all thinking things, all objects of all thought, and rolls through all things."

Electromagnetic Mechanisms.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A.

SOME PARADOXICAL CASES.

Passing on from these devices, I now invite your attention to another rather curious experimental result.

One consequence of the rule that the magnetic stress across a gap in the circuit is proportional to the square of the intensity of the magnetic flux is the paradox that the pull exerted on an armature by an electromagnet having a straight cylindrical core is diminished by enlarging the surface of contact, and increased by somewhat diminishing that surface. This seems to be in direct opposition to all ordinary notions of mechanical structures; but it is, nevertheless, quite rational. If we diminish the end surface of the core, say 10 per cent., we shall produce thereby really very little difference in the total flux of magnetic lines, since the main reluctance to magnetization lies in the long return path through the air. But if the flux of magnetic lines is now crowded into a lesser area, the intensity of the flux—that is to say, the number of magnetic lines per square inch—will be greater, and the

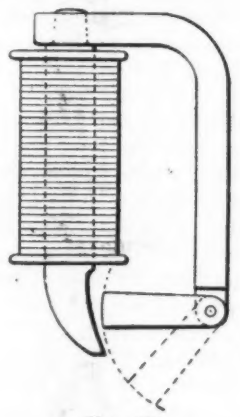


FIG. 10.

square of this quantity will be, *à fortiori*, greater still. Now the pull exerted at the surface is equal to the product of this greater square number into the diminished area of surface; and as the increase in the square of the induction is greater than the decrease in surface, the net result is that the pull is increased. Conversely, enlarging the contact surface diminishes the pull. This goes entirely against all preconceived notions of mechanical engineering; for the first instinctive impulse of an engineer when he wants to strengthen the joint between two things is to enlarge the surface of contact at the joint. Some diagrams that hang upon the wall (reproduced in my recent "Cantor Lectures") exhibit the results of a series of experiments by Dr. Julius Dub upon the deleterious effect of adding polar expansions to the end of an electromagnet.

Another strange and interesting fact is that the pull exerted upon a piece of iron by a straight electromagnet can be considerably increased by attaching a large mass of iron to the other end of the core of the electromagnet. This is at once explained by reference to the principle of the magnetic circuit, for the mass of iron at the idle end of the core aids in the return of the magnetic lines through the air.

EQUALIZERS.

I may now proceed to the consideration of sundry pieces of mechanism, in which an electromagnet in one or other of its varied forms is combined with some other contrivance of a mechanical nature. In the first place, I will deal with the subject of *equalizers*, or devices for equalizing the otherwise unequal forces exerted by an electromagnet on its armature when the latter is at different distances. You will have realized how, for example, with the ordinary two-pole or horseshoe form of electromagnet, the pull will become greater as the armature approaches, because as the gaps between it and the iron core are diminished the resulting betterment of the magnetic circuit both increases the actual flux of magnetic lines and diminishes the amount of magnetic leakage. The variations of this force cannot be accurately expressed by a law of inverse distances or of inverse squares or cubes, and I shall not attempt the hopeless task of trying to fit a law to them. If an armature placed below the poles of such an electromagnet at a little distance away is not constrained by any other opposing forces than that of its own weight, it is evident that there must be one particular strength of current which will just suffice to magnetize the electromagnet sufficiently to overcome the downward pull of gravity and raise the armature; but when once the armature has begun to rise, its mere approach betters the magnetic circuit and increases the upward attraction, so that it will be pulled right up to the pole. A strong current will perform no more in this case than one that is just strong enough to start the action. If, however, such an armature be controlled, not by the mere force of gravity, but by a spring so designed that, as the armature moves nearer to the poles, the opposing force

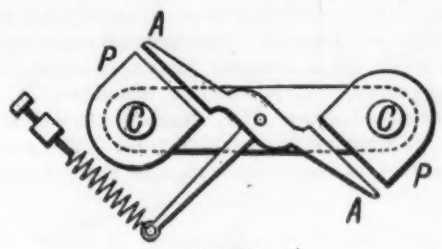


FIG. 12.

of the spring shall be greatly increased, then a weak current will only produce a small motion, and a stronger current a larger motion, and there will be a determinate position of the armature corresponding to all different strengths of currents within the working limits of the apparatus. It is clear, then, that a properly designed spring, or combination of springs, may be used to equalize the movements of the armature in more or less strict proportion to the electric current. A device of this kind, with a series of set screws behind a spring at different distances to stiffen it as it was moved, was indeed invented by Callaud, a French engineer. Another mode of equalizing is by a pair of rocking levers, which cause the armature as it approaches the poles to work with a lessened mechanical advantage. Equalizers on this plan were first suggested by the conjurer, Robert Houdin, and one used in the mechanism of several arc lamps. Another inventor, Burnett, has proposed to act on one armature by means of several electromagnets which should successively be brought into play. A purely electrical method of equalizing consists in arranging a series of contacts in the path of the armature, so that as it approaches the poles it should successively shunt out of action portions of the exciting current. Another device due to Froment consisted in applying a reversed Stanhope lever to the armature. Other varieties of linkage might doubtless be arranged to attain the same end. But the most interesting kinds of equalizers are those which depend on magnetic principles. It is possible, for example, by the device of shaping away the polar surfaces or by adding pole pieces of appropriate shape, to cause the approach of the armature to exert a very slight betterment of the magnetic circuit. One of such devices is depicted in Fig. 10, and consists in pivoting the armature to one pole of an electromagnet, the other pole of which is provided with a curved pole-piece. By varying the contour of the latter any desired change may be made in the distribution of the pull at various points of the

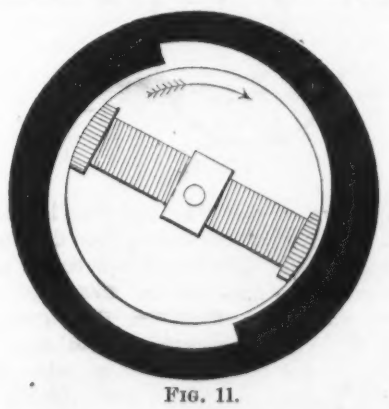


FIG. 11.

travel. In this particular instance, as the armature moves nearer, as a whole, it increases its distance from the curved pole-piece. An electromagnet resembling this is used in Messrs. Paterson and Cooper's Phœnix arc lamp.

DEVICES BASED ON OBLIQUE APPROACH.

It is not very easy to draw a hard defining line between this device and another, due to Froment, who pivoted his armature upon two parallel levers, like the connecting bars of a parallel ruler, and thus constrains the armature to move (parallel to itself) along a curve, which, though it approaches very near to the poles, falls short of actual contact. Devices with oblique approach have often been used in small electromagnetic motors. One of these, due to Wheatstone, is depicted in Fig. 11, in which it will be seen that an electromagnet, pivoted so as to revolve on its own middle, is surrounded by an iron ring through which the magnetic lines can stream back from the north to the south pole. The inner face of this ring is cut away in an oblique manner. Applying our principle that there is a tendency of the configuration so to alter as to complete the magnetic circuit as much as possible, it is evident that the electromagnet will turn until the gaps are reduced to a minimum. If at this point the current is cut off, the electromagnet will be carried on over the dead points, and may be again switched (automatically) into circuit, to be again attracted forward, and so forth. The analogy between this piece of magnetic mechanism and

*Presidential address to the Junior Engineering Society, London; concluded from the THE ELECTRICAL WORLD, Jan. 24, 1891.

the familiar mechanical device known as the cam will be at once apparent. This is by no means the only instance of an electromagnetic cam to be found among the practical applications of the science. All the electromagnetic devices for distributing the pull of an electromagnet, whether they consist in shaping the pole-pieces or the armatures, or whether they consist in constraining or pivoting the armature or the electromagnet in the modes previously suggested, may be considered magnetically as either cams, wedges, or inclined planes.

PIVOTED MECHANISMS.

Beside the devices which I have already mentioned there are several for producing movement about or upon an axis. Some of these are designed for telegraphic purposes. For example, in Fig. 12 is depicted the method adopted by Siemens 40 years ago for pivoting an armature, *A A*, between the two pole-pieces, *P P*, attached to the ends of the core, *C C*, of a horseshoe electromagnet. The particular form chosen leaves very narrow gaps in the magnetic cir-

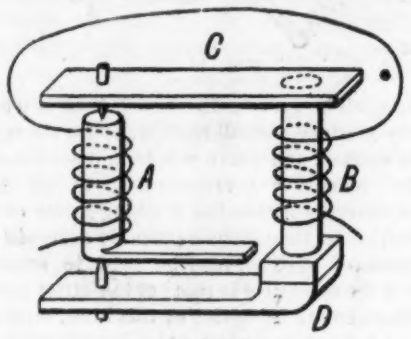


FIG. 13.

cuit, which, therefore, requires little current to magnetize it, making the arrangement very sensitive. Compare with this a device due to Waterhouse, of New York, shown in Fig. 13, who pivots one of the two cylindrical cores of the electromagnet, furnished with a projecting tongue, *A*. The other core, *B*, is provided with a larger tongue, *D*, of brass or other non-magnetic metal to support the lower pivot. If *A* is originally turned outward, the tendency of the magnetizing current will be to turn it back into parallelism with the support *D*.

MECHANISMS OF BELLS AND INDICATORS.

The mechanisms of electric bells, and those of the annunciators or indicators used in conjunction with electric bells, furnish a variety of examples of devices, all of which are readily comprehended by the aid of the principle of the magnetic circuit. A number of these I have upon the table. Here are a few indicators. In some of them a

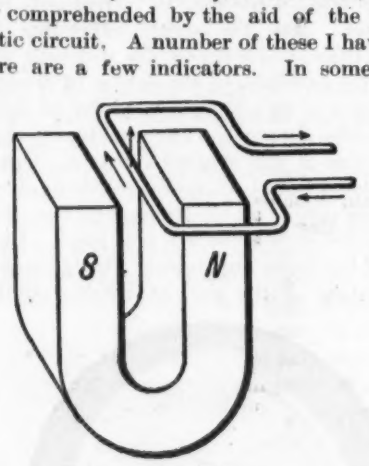


FIG. 14.

pendulum is drawn on one side, and then left to swing. In another, a trip lever, which carries a red disc, is latched up out of sight until the electric current comes and pulls down the latch. In another an armature pivoted between two flat polar faces is drawn up into a position where it can better carry the magnetic lines. Here is a small electric bell of unusual sensitiveness of action. It is different in construction from the ordinary type of electric trembling bell. The electromagnet, a horseshoe, lies horizontally. The armature is a flat plate of iron, pierced with two holes; by these it is hung upon two brass pins which stand out like two miniature hat-pegs from the polar faces of the cores. This armature is always in contact with the electromagnet, so that the magnetic circuit is, in one sense, always closed. But the spring attached behind keeps the armature from lying flat against the pole faces; it only touches along its edge. It can, therefore, better the circuit by tilting upon its pins, and in this manner it vibrates. Its great sensitiveness may be attributed to the way in which the initial position adopted aids the excitation of the magnetism.

POLARIZED MECHANISMS.

There is another set of electromagnetic mechanisms in which use is made of a permanently magnetized steel magnet, in addition to electromagnetic devices. One of these is illustrated by the sketch shown in Fig. 14. Here is represented an inverted horseshoe steel magnet, its north and south poles being indicated by the letters *N* and *S*. There will be a powerful magnetic field in the space between the two limbs, where the magnetic lines pass across from one limb to the other. If a loop of copper wire is placed over one of the poles, and the electric current is sent around the loop, it will be found to be acted upon by a mechanical force tending to drag it across the magnetic lines of the field.

In this device the direction of the motion will depend upon the sense in which the current is flowing in the loop of wire. If the sense of the flow be that indicated by the three arrows, the direction of the motion will be upward, as indicated by the fourth arrow. If the current is reversed, the direction of the motion will reverse. Now, this is quite different from the action of the ordinary electromagnet of soft iron, for in that case the core pulls at the armature in the same direction, no matter which way the current is flowing around its coils. To distinguish be-

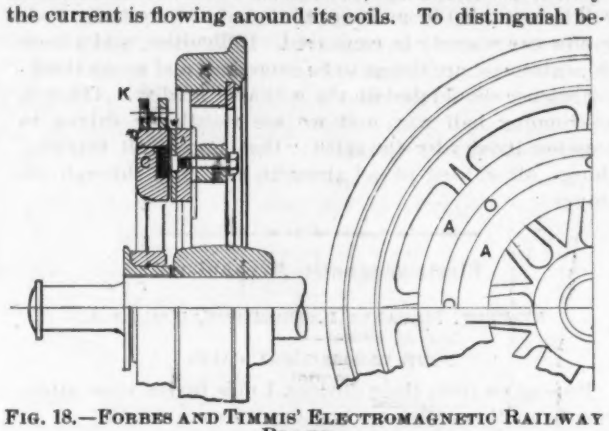


FIG. 18.—FORBES AND TIMMIS' ELECTROMAGNETIC RAILWAY BRAKE.

tween the two cases, it is usual to refer to those devices in which a permanent magnet comes into use as *polarized* mechanisms, while the ordinary electromagnets are *non-polarized*. One result of using a polarized mechanism is to secure uni-directionality of motion in correspondence with the current. The single acting mechanism is thus made into a double acting mechanism, a point the possible advantage of which every engineer will at once grasp. Sturgeon, the inventor of the original electromagnet, was himself the inventor also of a polarized mechanism intended to be used as an electromagnetic telegraph. It is shown in Fig. 15, and consists simply of a permanently magnetized steel compass needle placed with one pole between the poles of a soft iron horseshoe electromagnet. If the current is sent around the spiral coil from *N* to *S*, the left-hand pole will become a north pole and the right-hand pole a south pole, with the result that the north pole of the compass needle will turn to the right. On reversing the sense of the current the needle will of course turn to the left. It is strange that this invention, which Sturgeon gave to the world unpatented in 1836, was never brought into commercial use as a telegraph at a time when telegraphs were almost a monopoly in the hands of a few interested persons. Perhaps like some other unpatented inventions, of which Hughes' microphone is a notable example, it was appropriated by some other inventor by judicial stretching of his patent to cover what he never dreamed of inventing.

Another form of polarized mechanism is used in an electric bell upon the table, one of that species of electric bell which is worked without any battery by means of a little alternate current dynamo machine turned by a crank, and

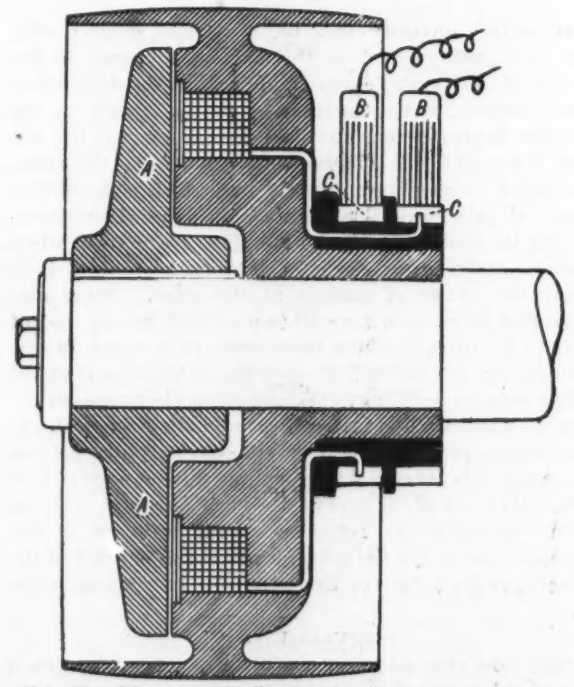


FIG. 17.—WYNNE AND RAWORTH ELECTROMAGNETIC CLUTCH.

known as a "magneto-generator." The alternate currents generated by this little machine when they reach the bell throw its polarized armature over alternately right and left, so that its rate of trembling depends on the rapidity with which the alternations succeed one another.

VIBRATORY MECHANISM.

The mention of electric bells suggests to me that there are numerous devices for producing a vibratory movement by electromagnetic means. Such are to be found not only in bells, but in the automatic breaks of induction coils and of electrically driven tuning forks. To enter upon a discussion of these would lead me too far afield.

ROTATORY DEVICES AND ELECTROMAGNETIC MOTORS.

Similarly, I must pass over the enticing topic of the rotatory devices used in electric motors, to one class of which, namely, those working by oblique approach, I alluded a little time back. But this class of motor is adapted only for use on a very small scale—practically only for toys. The larger motors, which, indeed, are nothing else than dynamo machines arranged to be used in the inverse function of doing mechanical work when supplied with electric energy through a wire, are never built on this plan. In these, the rotating armature is usually a complex electromagnet, built up symmetrically around an axis, with a core of laminated iron, and a peculiarly wound coil in which the current circulates in a manner governed by a commutator. I would that time allowed me to dwell on the electromagnetic motor, and on the points of correspondence and of contrast between it and the steam engine. But no, your patience will not last for ever, not even till midnight. So I must dismiss the motor with the remark that so long as designers of electric motors adhered too closely to the plan of steam engines, seeking to produce first a reciprocating action, and then to convert this by a crank into a rotatory motion, so long was the electric

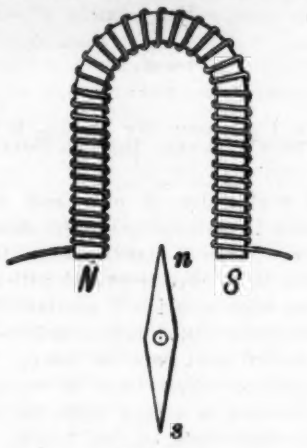


FIG. 15.

motor a mere toy, and that the real advance came when the lines of steam-engine design were abandoned and a true rotatory form of electromagnetic apparatus was adopted. But, strange to say, this advance came about in the hands of inventors who were not trying to invent a motor at all, but who, in perfecting the dynamo machine for producing electric light, found themselves in possession of a far better electric motor than any that had been specially designed as such.

AN ELECTROMAGNETIC SEPARATER.

Before closing this review of electromagnetic mechanisms in general, I must, however, describe some recent devices that are worthy of the attention of the engineer. The first of these is a *separater* or *sorter* for separating pieces of iron from any non-magnetic materials. Many such have been tried in industries of very various kinds: for preventing iron particles from getting into white china clay, for sorting iron filings from brass, for catching nuts and

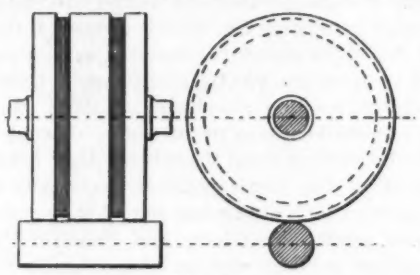


FIG. 16.

nails and other such things which are liable to stray into the disintegrators used by the manufacturer of artificial guano, and for selecting iron ore from mere earthy matters. The particular sorter that I have to describe to you is merely a revolving electromagnet of a peculiar circular type, invented long ago by Prof. Weber (Fig. 16), in which the coils are wound in grooves in an iron drum. This electromagnet is shown as being used with a cylindrical iron armature as a kind of rolling gear. In the separater in question there is no such armature; the drum merely rotates by steam in a sort of bed-plate, any iron scraps among the refuse that is thrown on to it being carried over to the other side, where they are removed mechanically.

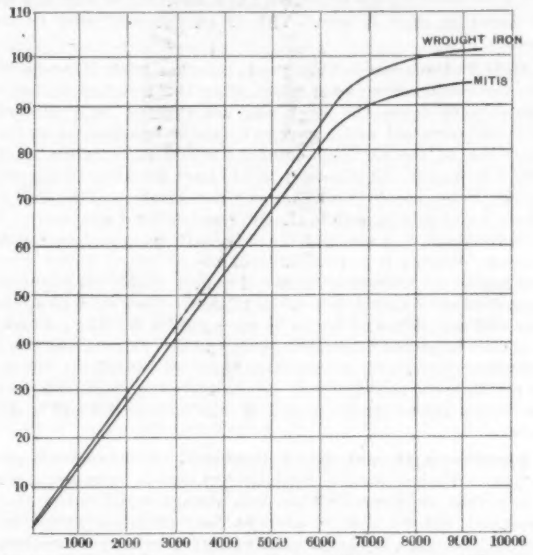
AN ELECTROMAGNETIC CLUTCH.

The next device that I shall allude to is an electromagnetic clutch (Fig. 17), constructed by the Brush Electric Engineering Company, under the patents of Wynne and Raworth. This clutch consists of a peculiar form of iron clad electromagnet, being, in fact, a loose iron pulley with an unusually solid body, in the face of which a deep and broad rim has been turned to receive the coils of insulated copper wire. Opposite this, acting as the armature, is a stout disc of soft iron, *A*, firmly keyed upon the shaft. The electric current is conveyed in and out of the coils by means of two metal brushes, *B B*, shown on the right, which press against two gun-metal collars, *C C*, embedded in insulating fibre, and which are connected respectively to the two ends of the coil. When it is desired to throw the clutch into gear, all that is needful is to turn on the current, when the electromagnet pulley at once grips the iron disc with a grip that may easily be made as much as 100 pounds per square inch of surface of contact, and the pulley forthwith turns solidly on the shaft. As the switch for turning on and off the electric current may be placed in any convenient position, either near or far away, it is obvious that this clutch presents many advantages

over the mechanical clutches—whether friction clutches or claw clutches—that need some kind of striking gear to be affixed to them. For clutches in inaccessible positions on a line of shafting this device is indeed superior to anything ever previously imagined.

AN ELECTROMAGNETIC RAILWAY BRAKE.

The last contrivance that I shall describe is shown in Fig. 18. This is the electromagnetic railway brake devised by Prof. George Forbes and Mr. J. Timmis. The ironclad electromagnet closely resembles that just described: the cord *C* is a ring of wrought iron, bolted securely to the axle-box by bolts passing through the holes *K*, and constructed with a deep groove to contain the coils. The armature *A A* is another ring of iron bolted to the carriage wheel. As in this case there will be much wear of the surfaces in contact, a renewable pair of iron washers, *W*, in two parts are interposed to serve as pole-pieces. If every wheel of every carriage of a train were provided with such a brake, these could be simultaneously thrown into action



MAGNETIZATION CURVES OF MITIS METAL AND WROUGHT IRON.

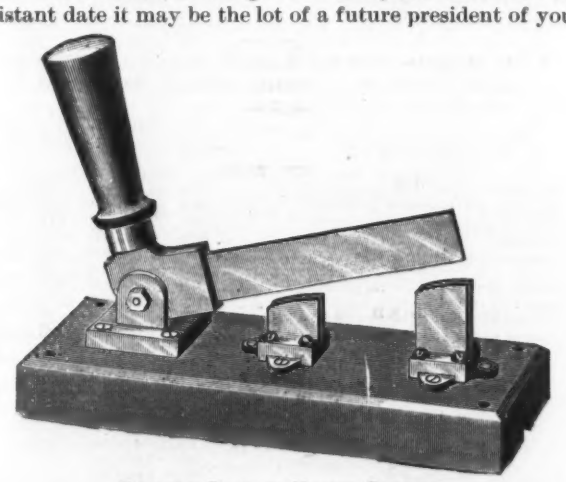
by merely turning on the electric current to the whole of them at once.

MISCELLANEOUS ELECTROMAGNETIC MECHANISMS.

Among the mechanisms that I shall not attempt to describe are those applied in electric locks, in the keyboards of electrically worked organs, in the electric weaving machinery, which will, I believe, ere long quite supplant the Jacquard loom, and in various other industrial applications. In all this I have said nothing about the peculiar properties of the alternate current electromagnet, a topic too vast to be entered upon here.

ELECTROMAGNETIC MACHINE TOOLS.

Nor have I time to do more than allude to the subject of electromagnetic machine tools, a subject which is destined to come to the front very shortly, now that the industrial supply of electricity is spreading so quickly. Upon the table are a number of blue prints and drawings relating to the machine tools of this class—electromagnetic drills, electromagnetic riveters, and the like—invented by Mr. F. J. Rowan, of Glasgow. Perhaps at some not very distant date it may be the lot of a future president of your



DOUBLE BREAK KNIFE SWITCH.

society to award its medal to some one of your members now present for a paper on electromagnetic machine tools, even as this year your medal has been awarded for one on hydraulic machine tools.

CLASSIFICATION OF ELECTROMAGNETIC MECHANISMS.

Now this wide topic of electromagnetic mechanism, into which I have endeavored to give you some insight, is one that requires to be reduced to a system. A classification I have, indeed, attempted, but it is as yet little more than an enumeration of the various forms. Such as it is I will print it with this address (see appendix), that you may at least know in outline what has been done in the way of classification. I have already gone further, and have attempted to aid the analytical and synthetical study of the subject by a sort of notation, which, however, is not yet in a shape fit for publication. The fact is that we want some one to do for the subject of electromagnetic mechanism what Willis and Reuleaux achieved for the subject of mechanical mechanism. It is nigh fifty years since Willis at Cambridge reduced to something like a system the subject of mechanism in general, which previously to his time had been subjected to no such systematic treatment. And it is nearly five-and-twenty years since Reuleaux, of whom your former president, Professor Kennedy, is the exponent in this country, produced that wonderful book, "The Kinematics of Machinery," in which all possible mechanical combinations are reduced to a system of kinematical pairs and chains. I am, as yet, very far from having analyzed down the topic of electromagnetic mechanism to a consistent system; and it is quite possible that I may not succeed in doing so. Yet, whenever the man and the hour arrive that shall achieve this, there will have been achieved a work of no little importance. For the systematization of knowledge is a work that brings in its own abundant reward in the fact that it always renders further practical advances possible in the not distant future.

APPENDIX.

ENUMERATION OF ELECTROMAGNETIC MECHANISMS.

I. *Electromagnets*—
- A. Fixed coil and core; moving armature.
  1. Short compact magnetic circuit, for traction in contact.
  2. Elongated circuit and heavier coil, for attraction at distance.
  3. Special forms: Iron-clad, club-footed, laminated, consequent, multipolar, etc.
- B. Fixed tubular coil and moving plunger.
  1. Plunger longer than coil.
  2. Plunger shorter than coil.
  3. Special forms of plunger, coned, laminated, etc.
  4. Coil constructed in sections for successive action.
- C. Intermediate forms.
- D. Fixed tubular coil and movable coil.

II. *Electromagnets with Opposing Forces*—
1. Counterpoise springs.
2. Counterpoise weights.

III. *Equalizers for Electromagnets*—
1. Electrical equalizers.
2. Set-up springs.
3. Rocking levers.
4. Linkage movements.
5. Cam equalizers with shaped polar faces.

IV. *Electromagnetic Cams*—
Devices depending on the lateral approach of a shaped polar surface.

V. *Electromagnetic Linkages*—
Devices depending upon the mutual interaction of two or more separate electromagnets.

VI. *Apparatus Depending on Electromagnetic Repulsion*—
1. Mutual repulsion of parallel cores.
2. Elongation of jointed or tubular cores.

VII. *Polarized Electromagnetic Devices*—
1. Electromagnet with parallel polarized armature.
2. Electromagnet with transverse polarized armature.
3. Coil with polarized plunger.
4. Polarized electromagnet with counterpoise spring (Hughes magnet).

VIII. *Electromagnetic Vibrators*—
- A. Non-polarized.
  1. Break circuit.
  2. Short circuit.
  3. Differentially wound.
- B. Polarized.
  1. Single acting.
  2. Moving part polarized.
  3. Fixed part polarized.

IX. *Rotatory Electromagnetic Devices*—
1. Coil fixed, needle moving.
2. Magnet fixed, coil moving.
3. Coil fixed, coil moving.
4. Electromagnet with obliquely pivoted armature.
5. Wire rotating around magnet pole.
6. Copper disc rotating between magnet poles.
7. Pole rotating round conducting wire.
8. Magnet rotating on itself when carrying current.
9. Curved tubular coil and S-shaped plunger.
10. Oblique approach of armature.
10*a*. Wheatstone's cam armature.
10*b*. Froment's armature constrained around centre.

X. *Electromagnetic Adherence*—
1. Magnetic friction gear.
2. Magnetic brakes for vehicles.
3. Magnetic clutches.

XI. *Alternate Current Devices*—
1. Copper conductors repelled from pole.
2. Shading of pole by copper screen.
3. Vertical rotation of magnetic field by two currents at angle in different phases.

Mitis Metal for Dynamo Magnets.

Mr. Claude W. Hill, in a letter to the London *Electrical Review*, calls attention to the curves which he has obtained with mitis metal field magnets. In 1887 he constructed a dynamo with magnets made of this metal and afterwards had a set of wrought iron magnets made for the same machine exactly similar to the ones made of mitis metal. The characteristic curves which he obtained by experiment, the same armature being used in both cases, and the machine being operated under exactly similar conditions, are shown in the accompanying cut. The readings were taken with Sir William Thomson's graded galvanometers.

Double Break Knife Switch.

This switch is designed for large current capacity and quick break. It is of the best material, construction and finish. The rating is made to allow a large margin of capacity. It has clamp terminals which will hold a large range of sizes and give secure mechanical and electrical contact. While not designed entirely for a high-tension switch, the action is such that it is claimed that it can be used for a voltage up to 500. It is placed on the market by The Electrical Supply Company, of Chicago.

High-Pressure Transmission of Power Experiments.

Some important experiments were carried out recently at Oerlikon by Mr. Brown with a view of demonstrating to officials of the German telegraph department and others the feasibility of high-pressure transmission of power. A has been announced, it is proposed to electrically transmit 300 h. p. from Lauffen-on-Neckar to Frankfort-on-Main, a distance of 100 miles, in connection with the Frankfort Exhibition, and the government has been asked to supply the line for that purpose. An artificial line four and a half miles long was employed in these experiments, and pressures of 15,000, 20,000 and 33,000 volts were tried, step-up transformers being used at the transmitting end and step-down transformers at the receiving end. The experiments were carried out during a severe snowstorm.

The Brewster Trolley Wire Clamp.

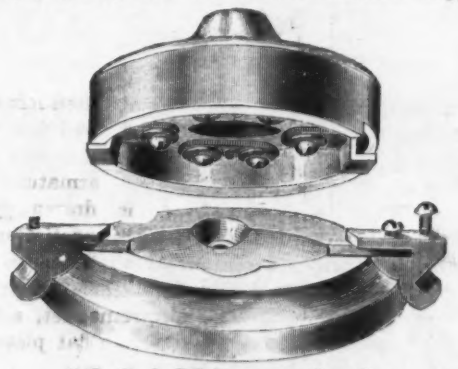
This clamp, which is put upon the market by the Electric Merchandise Company, of Chicago, is made of two pieces of hard and tough brass riveted together with a steel

TROLLEY WIRE CLAMP.

pin and can be placed on the line in a moment's time, and the insulator being screwed on, no soldering or hammering is required. When it becomes necessary to adjust the insulator, it is very easy to unscrew the insulator, when the desired position can be obtained. This clamp, on account of its simplicity and neatness, is claimed to be of very great use on railway line construction. The "Brewster" clamp will be furnished for any desired style of trolley hanger.

The "E. E. & S." Rosette.

The Electric Engineering and Supply Company, of Syracuse, N. Y., has just been putting upon the market a new porcelain rosette cut-out, which is attracting attention on account of its substantial design and neatness of finish. The porcelain base, which is also manufactured in Syracuse, is said to be particularly tough, and will stand hard usage, obviating trouble often experienced by linemen who, in screwing up cut-outs, crack the bases. The connections are milled smooth, so that the ears in the cap, to the opposite end of which the fuse is connected, fit in the slot milled into the side connection brasses, one ear of which enters at the side, as shown in the cut, with one screw and the other ear by swinging the cover round is pressed into the slot on the other side of the rosette until it is stopped by



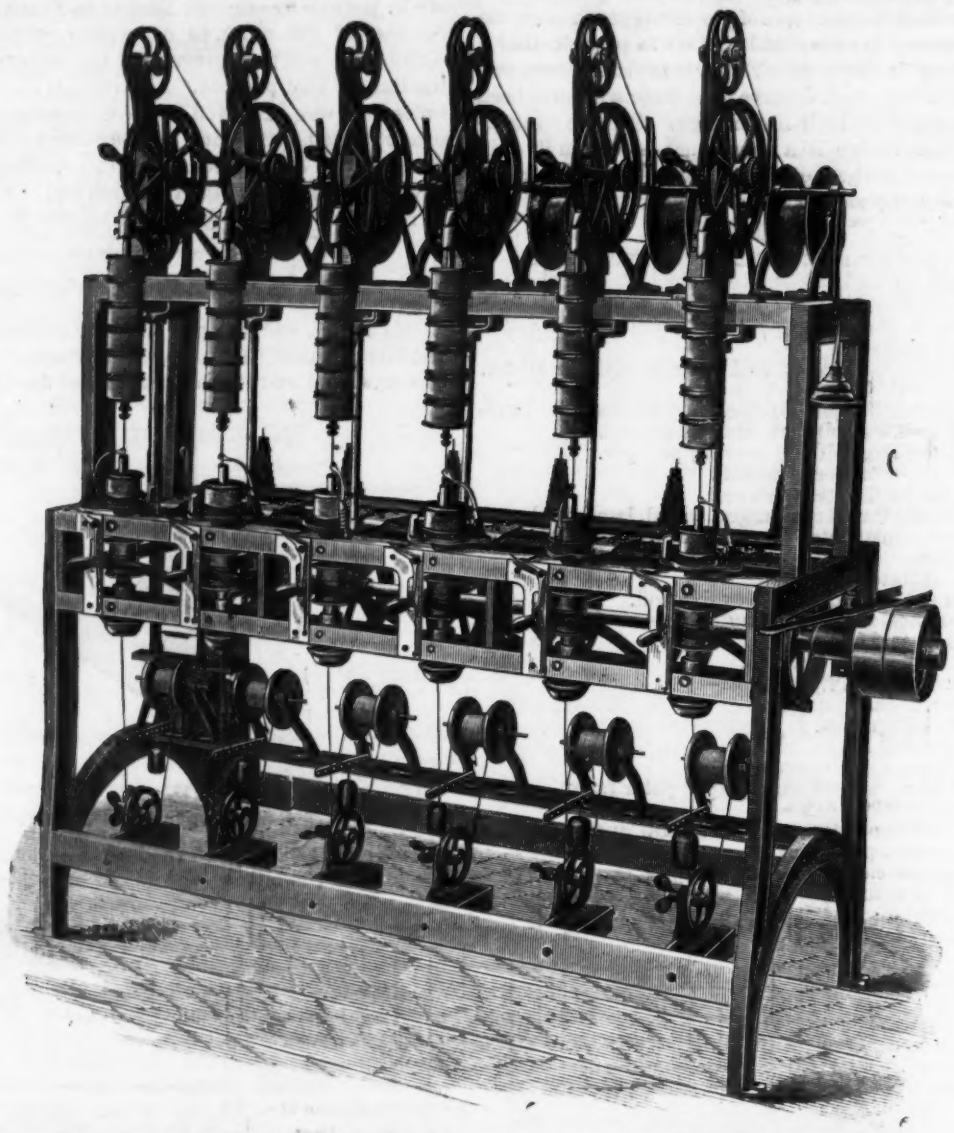
"E. E. & S." ROSETTE CUT-OUT.

the porcelain when it has reached its proper place. A one-half turn of the screw then clamps the cover in position. With this design of cut-out it is claimed that very rapid work can be done, as it is only necessary to make the usual connections, after which the cap is put in place, when the one-half turn of the screwdriver permanently clamps the cap in position.

A New Wire Covering Machine.

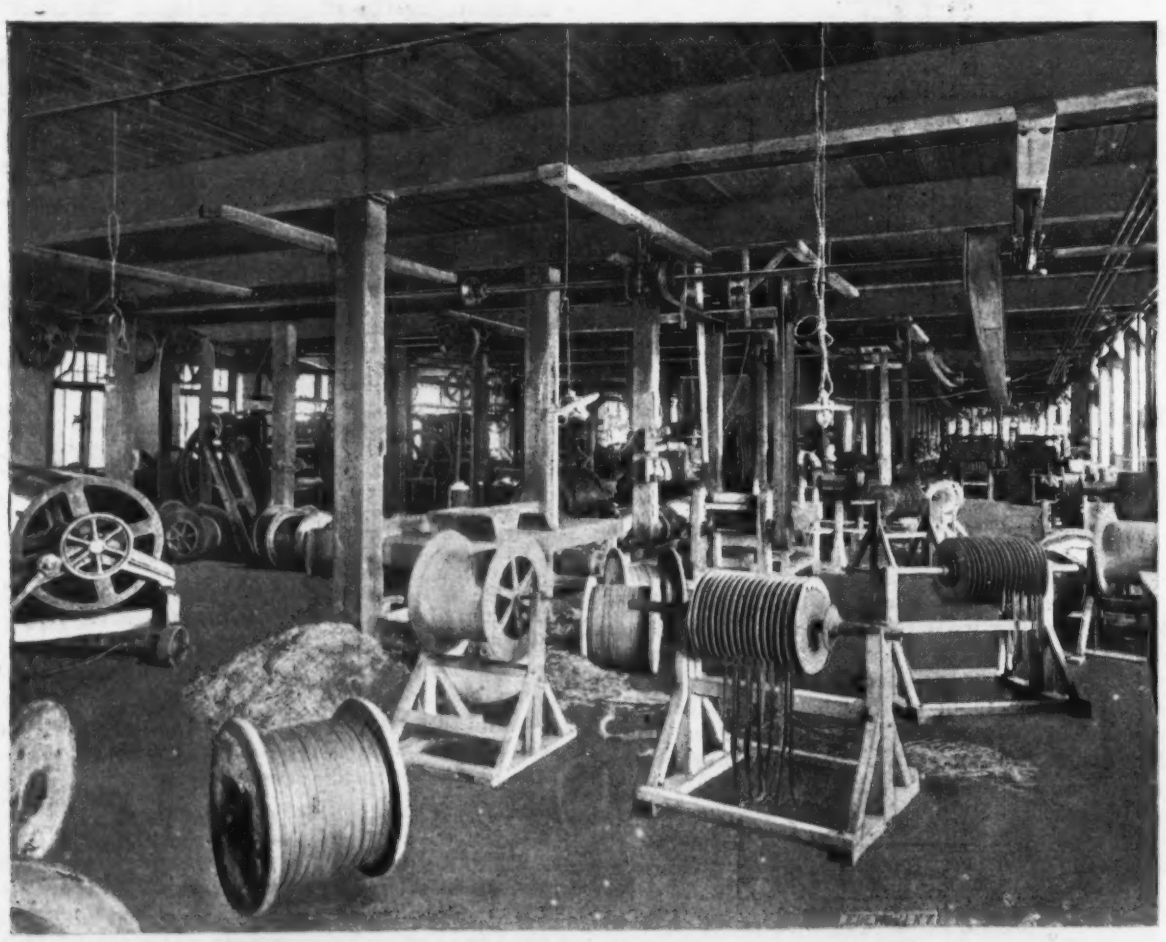
In the illustration on the next page is shown a new machine for covering the smaller sizes of electric wires with either silk or cotton insulation. The machine is manufactured by the New England Butt Company, of Providence, R. I., and is what is known as a "six-spindle flyer winder," and possesses some new and ingenious features. The construction of the machine is such as to secure the highest possible speed consistent with good work, the finest silk or cotton being laid on uniformly so as to secure the least possible thickness of insulation. The head and winding point of the machine are its principal features, having a fine adjustment for tension and for the different sizes of wire. The spool being on the spindle permits of high speed. A novel

feature is the reserve supply of full spools of silk or cotton insulation to take the place of empty spools as they run out, the change from the empty spool to a full one being made without cutting the wire. A simple arrangement is provided for changing the speed of the take-up wheel and also for turning back to mend or splice a broken wire. The



WIRE COVERING MACHINE OF THE NEW ENGLAND BUTT COMPANY.

covered wire is wound on a reel at the back of the machine, on which it is laid uniformly by a transverse motion. Each spindle is independent, so that different sizes of wire can be covered at the same time, and each has its own stop motion, so that when the thread breaks or a spool runs out the machine stops. Wide variations of speed are obtained by



VIEW ON THE FIRST FLOOR OF THE INTERNATIONAL OKONITE COMPANY'S FACTORY.

the use of gear wheels of different sizes, which are provided with the machine. It may be mentioned in this connection that orders for this machine have been received from England and Spain, and are now being filled. As an invitation has been issued by the company to the members of the National Electric Light Association to visit its works while in Providence the apparatus will probably be shown in operation to those who are interested in this particular class of machinery.

The Factory of the Okonite Company.

The accompanying illustration gives a very comprehensive view of the first floor of the International Okonite Company's factory at Passaic, N. J. Here the crude rubber is received, washed, mixed and the insulating compound known as okonite manufactured. In the foreground on the left is shown one of the large drums on which the Okonite covered wire is wound after coming from the covering machines, the whole being then placed in the vulcanizing ovens, where it is subjected to a temperature of 275 degrees an hour, the heat being effected by turning the steam directly into the vulcanizers, the vulcanizing being done with the Okonite covering in position on the wire. This is one of the most interesting departments of the factory and is equipped with much high class machinery, designed expressly for the manufacture of the Okonite specialties. The engine and boiler room, not shown in the illustration, is 80 × 50 feet, and adjoins the factory proper. In it are placed the dynamos for lighting the factory and a Thomson electric welding machine for the company's use.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

Electrical Stocks Strong.—Electrical securities have been receiving a great deal of attention from purchasers this week, and have had a good market. The railroad share market, on the contrary, has furnished little encouragement to purchasers. Lower prices have been the rule for some time past. The chance to make money on electric stocks is at present far beyond the ordinary.

Stocks are not at high prices, by any means, and the prospect of a rise is good. The electrical business generally is in good condition, and factories are running on full time.

Buying on margin in the case of electric stocks is limited, and hence there is less manipulation. Dealing in margins generally hurts more than it helps. If a stock is bought outright and put away when the market is "off," enhancement in value will surely come around. Many people make the great mistake when buying stocks of purchasing more than they can comfortably carry, and are sometimes forced to sell part at a sacrifice on a falling market in order to raise money. This is an excellent way to lose all profits.

Bell Telephone.—This stock, together with Western Union, showed remarkable power when, after the tremendous loss by the recent snow storm, the stock was not affected. If a railroad accident had occurred which gave evidence of one-quarter of the loss, the stock of the railroad company would have fallen so rapidly that a large amount of money would have been lost to buyers of its stock. Some people think that at the expiration of the Bell patent lively times will be seen in the different fields of telephony. So far as is apparent, it seems that the only really serious chance of danger to the company is a possibility of the Western Union Company coming in as a competitor, as the Bell people are pushing their long-distance construction to the utmost. They seem to appreciate this and are endeavoring to be prepared for it. The company will probably be forced to cheapen rates and the private and household telephony may partly go into the hands of outsiders; but it must be remembered that the Bell people have the plant, and the rights for wires are all secured, and it will be very difficult to displace them.

Thomson-Houston.—A director of the company is reported to have said recently that business had been a little slack, for the reason that on account of the late stringency of money the company had not felt able to give as long credits as formerly. But the outlook was very bright, especially for railway apparatus. The orders on hand and in sight were declared enormous, and the prospects were favorable for as good profits in 1891 as in the past. It had been expected that the high ratio of profits to gross sales must fall off, but it had not from the beginning. Occasionally, as in case of the contract with the West End Railway Company of Boston, where the business was for spot cash and there was a good advertisement in the contract, the figuring on profits was closer than in most instances, but the Boston contracts paid the company well. There was very close figuring against the Sprague Company in the latest Boston contract, but the Thomson-Houston Company secured it. As a rule there was not much competition between the electric manufacturing companies, the field being so large that there was room for all. The rise in the Series D stock is because of the possibility of its becoming a regular dividend-paying stock.

United Electric Securities Company.—The statement is made that $100,000 of this company's collateral bonds have been redeemed. The amount paid is not stated. This company is a Thomson-Houston organization.

Thomson-Houston.—This stock has not been particularly active this week. It closed ex-dividend 45, which is one and a half points below last week.

Edison stock closed at 102, which is one-half a point above last Saturday's closing. This stock has recently, however, gone to 111, and its present market price represents quite a fall. In view of its recent high prices, Edison stock is cheap at market price. It recovers very quickly. F. Z. M.

E. Z. Maguire & Co., electrical securities, 18 Wall street, send closing quotations of electric stocks Friday, Feb. 13, 1891, in New York, Boston and Washington:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co.	100	86,200,000	80¼	80¾
American Telegraph & Cable	100	14,000,000	83	85
Central and South American	100	5,000,000	145	160
Mexican	100	2,000,000	210	....
Commercial Cable Co	100	7,716,000	104	108
Postal Telegraph Cable	100	5,000,000	39	41
Edison General Electric Co.	100	15,000,000	102	107
Consolidated Electric Light	100	1,922,400	....	....
Edison Electric Illuminating Co.	100	2,567,800	79	80
United States Electric Light	100	1,500,000	30	....
North American Phonograph	100	6,200,000	....	12
BOSTON.				
Thomson-Houston Electric Co.	25	6,000,000	*15	46
" " preferred	25	4,000,000	25½	26
" " Series C	10	400,000	....	13
" " Series D	10	120,000	6½	7
" International Co.	100	1,000,000	....	....
Thomson Welding Co.	100	1,000,000	....	200
" European Welding Co.	100	1,000,000	60	67
Ft. Wayne Electric Co.	25	4,000 000	11⅝	12
Westinghouse Electric Mfg. Co.	50	5,000,000	11⅝	12
Telephone:				
American Bell	100	12,500,000	191	192
" " rights	..	.....	17½	17⅝
Erie	100	4,800,000	*47	....
New England	100	10,304,600	50½	....
Mexican	10	1,280,000	65c.	75c.
Tropical American	10	400,000	....	1.20
MISCELLANEOUS.				
Edison Phonograph Doll	10	1,000,000	....	1
WASHINGTON.				
Pennsylvania Telephone	50	750,000	25	34
Chesapeake & Potomac	100	2,650,000	56	....
American Graphophone	10	600,000	8¾	9½
United States Electric Light (Washington)	100	300,000	140	148½
Eckington and Soldiers' Home Electric Ry.	50	352,000	56	59
Georgetown and Tennallytown	50	200,000	60	63¼

* Ex-dividend.

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$240@$250	Cumberland	$60@ $62
Central Union	56@ 58	Wisconsin	118@ 120
Michigan	90@ 91	Bell of Missouri	160@ 165
Great Southern	30@ 37	Iowa Union	20@ 22
Colorado	34@ 38	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		
ELECTRIC LIGHT STOCKS.			
Chicago Arc Light and Power	$97@$98	Chicago Edison	$135@$150

NEW INCORPORATIONS.

Waco, Texas.—The Waco Water, Light and Power Company has been incorporated, with a capital stock of $500,000.

The Baltimore (Md.) Electric Refining Company, with a capital of stock of $500,000, was incorporated last week by Charles F. Mayer, William Keyser and others.

The Montrose Electric Company has been incorporated at Chicago with a capital stock of $100,000 to furnish light, power and heat. The incorporators are A. H. Floaten, F. M. Longfellow, A. A. Adair, H. H. Williams, B. A. Long and A. B. Lewis.

The Eckert Electric Manufacturing Company has been incorporated in Newark, N. J. The company will manufacture electrical goods. The capital is $300,000. The incorporators are: William H. Eckert, New York; James M. Seymour and Lewis Seymour, East Orange.

The Commercial Electric Company, Limited, has been incorporated for the purpose of supplying electric light and power in Brooklyn. The company has a capital of $5,000, all of which is to be common stock. The incorporators are H. Carlton Radford, Jeremiah P. Robinson, Frank P. Sturges and Elect Norton.

AFFAIRS OF THE COMPANIES.

The Southern Electrical Manufacturing and Supply Company, of New Orleans, La., has declared a dividend of 10 per cent.

The Pumpelly Storage and Electric Motor Company has been thoroughly reorganized, and will, with a few changes in the management, resume its former business. Facilities for the manufacture of its well-known accumulators on an increased scale have been provided, and it is confidently expected that nothing more serious than a loss of time will result from the recent unfortunate experience of the company.

The Brookline (Mass.) Gas Light Company, which also operates an electric light plant, has voted to issue $350,000 5 per cent. twenty year gold bonds secured by sinking fund, and also $500,000 new stock. Stockholders of record February 28 will be given the right to subscribe for $250,000 bonds at par, in proportion to their holdings, before April 1, one $1,000 bond to each twenty shares of stock. Holdings not multiples of twenty shares may be adjusted by purchase or sales of rights.

The United Electric Equipment Company, of Philadelphia, incorporated in 1890 in New Jersey, made an assignment on the 6th inst., for the benefit of creditors, to Henry N. Almy. It was recorded on Saturday. It conveys no real estate, and was made in pursuance of a resolution adopted at a special meeting of the board of directors. The reasons set out are that the company is unable to discharge its just debts; that some creditors have sued it and may soon obtain judgment and issue execution thereon, and that it is desired to treat all of its creditors alike. The deed bears the seal of the company, and is signed by B. Masden Vaughan, president, and attested by Henry N. Henry, secretary.

The Allegheney County Light Company, of Pittsburgh Pa., held its annual meeting on the 9th instant. The election of directors resulted in the choice of Geo. Westinghouse, Jr., A. M Byers, Robt. Pitcairn, C. L. Magee, Theo. Sproull, J. E. Ridall, William Eberhardt and H. G. Blaxter. The last four gentlemen are new directors, replacing Messrs. H. H. Westinghouse, John Caldwell, Chas. Paine and C. H. Jackson, retired. Mr. Geo. Westinghouse, Jr., was elected president to fill the vacancy caused by the resignation of his brother, Mr. H. H. Westinghouse. A printed statement of the company's affairs shows that in 1890 its net earnings were $67,189.06, against $47,322.96 for 1889, and $15,303.29 for 1888. The total assets were $1,226,408.06, and the total liabilities $1,154,439.73, leaving undivided profits amounting to $71,968.35. Bills and accounts payable on Sept. 30, 1890 amounted to $425,866.84, and on Dec. 31 were $380,554.58. On Dec. 31 the company was operating 33,500 16 c. p. lamps and 857 arc lamps of 2,000 c p. Since Dec. 31 applications have been received for an additional 2,000 incandescent lamp.

Brush Company Turned Over to Thomson-Houston Company.—At the annual meeting of the stockholders of the Brush Electric Company, held in Cleveland last week, the formal act of turning the plant over to the Thomson-Houston Company took place. Mr. George W. Stockly, president of the Brush Company, Mr. Charles F. Brush, General M. D. Leggett, and Mr. James J. Tracy, members of the board of directors, retired, and their places were filled by the election of representatives of the Thomson-Houston Company. The directors elected by the stockholders were as follows: Silas A. Barton, John S. Bartlett and Charles A. Coffin, of Boston; Charles S. Pease, of Pittsburgh; Myron T. Herrick, William B. Bolton, and Jonathan Potter, of Cleveland. Messrs. Barton, Bartlett, Coffin, and Pease represent the purchasers of the control of the Brush Company, the first three being directors in the Thomson-Houston Company. Mr. Potter represents the remaining interests of Mr. George W. Stockly and Mrs. John E. Cary. Mr. Bolton and Mr. Herrick were made members of the directory because it was thought best to have resident members. At the meeting of the directors Mr. Barton was elected president, Mr. Bartlett first vice president, Mr. Coffin second vice-president, Mr. Potter treasurer, and Mr. Bolton general counsel. Mr. Pease was elected general manager. He was for a number of years acting vice-president and general superintendent of the Westinghouse Company, Pittsburgh.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, Feb. 14, 1891.

The Syracuse (N. Y.) Electric Supply Company is wiring the new City Hall in that city for electric light, using Grimshaw wire throughout.

Messrs. Taylor & Son, who have lately introduced to the trade the Taylor primary battery, are meeting with great success in the sale of this efficient cell.

The New York Insulated Wire Company has received a large order for line wire from the Brush Electric Light and Power Company, of Savannah, Ga.

Telegraph Club's Ladies' Day.—Ladies' reception day at the New York Telegraph Club next Tuesday will be made particularly interesting for the fraternity. The programme includes singing, dancing, etc., and an exhibition of S. R. Lambden's famous music box.

The Cornell Electrical Engineering Company has opened offices at 45 Broadway, New York. This company is well known as contractor of street railways, one of the most recent being an Edison road at Hamilton, Ohio. Mr. C. L. Cornell will manage the New York offices.

The Robinson Electrical Works, of Albany, N. Y., has secured the contract to wire the fine new fire-proof building erected by the Delaware and Hudson Canal Company, on Pearl street. The building will be lit entirely by electricity, and will be wired throughout with Grimshaw white core wire run in interior conduit.

Mr. George W. La Rue, formerly the New York agent of the Sprague Electric Railway & Motor Company, is now the general sales agent of the Crocker-Wheeler Motor Company, and is doing a good business in the sale of that company's motors. His long experience with electric motors under all conditions makes him an excellent salesman.

The Walker Electric Company will be represented at the Providence Convention by Mr. Walker and Mr. Truax, who will exhibit to the members the new Walker meter, as arranged for alternating circuits. Many recent improvements have been made, and these, with the meter in operation, will be shown in the exhibition hall. A pamphlet recently published will be distributed for the information of visitors at the exhibition.

Consolidation Denied.—Pittsburgh dispatches to the New York papers to-day report the consummation of the rumored consolidation of the Thomson-Houston and Westinghouse companies. Concerning this the following authoritative statement was made by the representative of the Westinghouse Company in this city: "There is absolutely no foundation for the statement that any arrangement has been made or contemplated looking toward the control of the Westinghouse electrical interests by either the Thomson-Houston or the Edison companies. It is true that a good deal of stock in the Westinghouse Electric and Manufacturing Company has been purchased in Boston during the last two weeks, but those purchases have not been made in the interests of the Thomson-Houston Company, but by investors who have confidence in Mr. Westinghouse and the future of his electrical enterprises."

L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Feb. 14, 1891.

Birmingham, Conn.—The electric light plant is now in operation.

Fall River, Mass.—The electric railway under consideration, it is reported, will be devoted exclusively to freight traffic.

Large Isolated Plant in Thompsonville, Conn.—There is being completed for the Hartford Carpet Company what is said to be the largest private electric light plant in the state, the number of lights being about 2,300.

The Middlesex Electric Light Company, of Lowell, Mass., at the annual meeting, held recently, created the office of vice-president, and a new board of directors was elected for the ensuing year, with G. W. Fifield, president, and W. A. Ingham, vice-president.

The Hatherly Street Railway Company, of Abington, Mass., has asked the Board of Selectmen of that place for a new location. It is proposed to build a direct line between Rockland and Brocton, but it is thought the scheme will be opposed by the business men of the two places.

Gloucester, Mass.—The attachment on the Union Elecitic Traction Company, of Gloucester, by the Pettengill-Andrews Company and the Phœnix Iron Company has been dissolved. The property has passed into the hands of the Gloucester Street Railway Company, which will equip the line with the single trolley.

The West End Street Railway Company, of Boston, represents an outlay of over $16,000,000. The Thomson-Houston Company has just closed a contract with this company for 34 generators of 480 nominal h. p., or a total of over 16,000 h. p., costing in round numbers about half a million dollars.

The New England Telephone and Telegraph Company has been granted location for its poles in Boston, but with certain restrictions. The poles must not be more than 50 feet high, and not less than 15 inches in diameter at the base, and to be strung with not more than 80 wires and two cables.

Banquet and Ball.—The American Electrical Works, of Providence, is arranging to handsomely entertain the members of the association with a banquet and ball, in the factory, on Thursday, February 19, and there is no doubt but that it will prove as successful as everything that Mr. Phillips, of this company, has ever undertaken.

Mr. W. C. Fish has recently become connected with the management of the Bernstein Electric Company, associated with Mr. H B. Cram. Mr. Fish has had a varied electrical experience, both practical and technical. He has recently returned from abroad, where he had been interested in electrical development in various directions.

Lighting of Hyde Park, Mass.—We notice that the town of Hyde Park has advertised for bids for lighting its streets. The town has always enjoyed a very low contract from the local company for doing this work. The local company has made a contract with the selectmen of the town for seven years on very low prices. This contract was subject to ratification by the citizens. At a recent meeting called a certain class of the citizens of the town were there in large numbers and voted to accept the contract, provided the company would make it at the same prices for three years; and in event of their not doing this the selectmen were instructed to ask for bids. This meeting did not represent the heavy taxpaying element of the town, and the feeling among all the citizens is in favor of the long contract; but the selectmen, in accordance with the vote of this meeting, have advertised for bids. At the prices which the company has offered and considering the many complications of the Massachusetts law protecting the right of electric companies, it would seem a waste of time for any company to bid under this proposal. The territory to be covered embraces almost 30 miles of streets, and under no circumstances can a party obtaining the street lighting do any commercial business in the town. C. A. B.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 CITY BUILDING, PHILADELPHIA, Feb. 14, 1891.

Morris, Tasker & Co. have the contract to furnish electric light poles to the city for the year 1891.

The Pennsylvania Railroad near Philadelphia is to be brilliantly lighted with electric lights for a distance of seven miles.

Messrs. Chadbourne, Hazelton & Co. are equipping a five-mile electric railway for the Athens Street Railway Company, Athens, Ga.

The S. S. White Dental Company, of this city, has purchased the patents and the right to manufacture and sell the Partz battery, including the "Acid Gravity," "Motor," "Medical," "Porous Cell Acid Gravity," and "Sulphur Chromic Salts" cells.

Two Ball Engines of 100 h. p., tandem compound, manufactured by the Ball Engine Company, of Erie, Pa., are furnishing power for the new station of the Columbia Avenue Electric Light Company, located on Columbia avenue, Philadelphia, Pa. Mr. J W. Parker is the Philadelphia agent of the Ball Engine Company.

Chief Walker, of the Electrical Bureau, sent in a report last week to Mayor Fitler for transmission to the National Capital. This was done in response to a request from Washington for statistics of electrical matters and information on the methods adopted by the municipal authorities in this city. As far as Councils have allowed him to go, the chief considers that Philadelphia is ahead on electrical management. The paper he prepared was practically a second edition of the annual report, and gave an idea of how the entire electrical business of the city is managed.

Queen & Co., of Philadelphia, inform us that their exhibit at the Providence meeting of the National Electric Light Association promises to be most interesting. They will show a full line of their special instruments, and also a series of their new magnetic vane ammeters, which are specially intended for central station use. Regarding these ammeters, the Brush Electric Company, of New York, says in a recent letter: "We very cheerfully state that your ammeters as used by us have worked accurately and given satisfaction." Queen & Co. have just completed negotiations with Profs. Bristol and Geyer, of Hoboken, for the control for their patent, which covers a new form of recording ammeter. These instruments are not yet perfected, but they promise well, and there is certainly a demand for a reliable recording meter. Mr. E. G. Willyoung expects to look after the interests of the firm of Providence, and will be much pleased to receive a call from those in attendance and their friends.

W. F. H.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, Feb. 14, 1891.

Union City, Ind.—The Union City Electric Light and Power Company desires bids on an incandescent plant.

Mr. F. D. Rusling, formerly with the Elcelsior Electric Company, is now with the Thomson-Houston Electric Company at Kansas City, Mo.

Mr. A. H. Zenner, of Omaha, Neb., is now representing the Electrical Supply Company, of Chicago, in Iowa, Nebraska, Kansas and South Dakota.

Mr. J. P. Barrett's appointment as the head of the electrical section of the World's Columbian Exposition has been confirmed by the Commissioners.

Messrs. Treat & Foltz have been selected by Chief of Construction Burnham to design the building for electrical exhibits at the Columbian Exposition.

A Combination Plant of 50 arc and 500 incandescent lights is being erected for the When Clothing Company, Indianapolis, Ind., by the Fort Wayne Electric Company.

Mr. Frederick L. Merrill has secured the Chicago agency for the Consolidated Electric Storage Company, of New York, and the Loomis system of arc and incandescent lighting.

Two State Institutions to Adopt Electric Light.—The State Institution for the Blind and the State Insane Asylum at Indianapolis are open for bids for combination arc and incandescent plants.

Mr. F. H. Soden, of the engineering department of the Thomson-Houston Company at Chicago, has been appointed as engineer to have charge of electric construction under Chief of Construction D. H. Burnham.

St. Paul, Minn., was visited by a small blizzard on Sunday last. Trains were generally late and traffic practically abandoned. While the operation of the electric lines was seriously hindered, yet the cars continued their trips during the night.

Mr. C. A. Ross, agent at Kansas City, Mo., for the Thomson-Houston Electric Company, reports the sale of one 50-light 2,000 c. p. arc machine and one 650-light alternating incandescent dynamo, together with the installation outfit for both.

City Contracts Not Made.—The contracts for the city lighting in Indianapolis have not yet been made. It was generally understood that formal action would be taken on the 4th inst., but the matter was postponed owing to a misunderstanding which arose regarding the conditions imposed by the city.

Stopping Horses by Electricity.—Fully 250 horse owners and men interested in the animal witnessed Saturday afternoon an exhibition of Holson's electrical device for stopping runaway horses. The test was made on North Park avenue boulevard near Fullerton avenue, and was in every respect successful. The scheme is so simple that any one can operate it. The experiments were conducted by A. B. Holson, the inventor. Two powerful horses attached to a carriage were driven smartly down the boulevard. Suddenly the driver dropped his reins and applied the whip. The animals were on the full run when the inventor, who was in the carriage, pressed a button. The team began a series of spasmodic buck jumps, coming to a standstill within a distance of 30 feet from the point where Mr. Holson completed the electric current. Beneath the seat of the carriage is a small battery. Wires lead from this through the reins to the bit. A button within the vehicle and another on the driver's seat can be so operated as to complete the circuit to the horses. The strength of the current is slight, the pressure being but four volts, and checks the horses without in any wise injuring them. The button inside the carriage is for use in case the driver is thrown off, or is not in his seat at the beginning of the runaway. Other wires also pass along the carriage pole and are connected with martingales, which are attached to the bit. If the lines should break or fall the electricity may thus be conveyed to the horses' mouths. The inventor claims that the use of the electric current does not harm the horses in the least, and attributes their sudden stopping to surprise. They are so astonished at the sensation in their mouths that they forget to keep on running.

H. C. E.

CINCINNATI, O., Feb. 14, 1891.

The City Council is agitating the question of lighting the entire city with electricity. Already the large parks have been dotted with globes and crossed with wires.

The Central Union Railway, Depot and Bridge Company has just built a fine large brick structure on Smith and Third streets for the electric light plant to light the depots and the great Huntington bridge across the Ohio.

The arrival of electric cars from Covington, Ky., across the Ohio river suspension bridge was a notable event on Sunday. Thousands crossed the river either way for the novelty of the ride. After a long fight in the legislature and the courts the bridge fares have been reduced, and with the electric road now binding the two cities

together Covington promises soon to have a population of 60,000 persons.

Covington, Ky., proposes to take another step forward by building an electric line through West Covington, on the south side of the Ohio, to Ludlow. This will immediately open up a mile square of valuable property not one mile from the Custom House in Cincinnati. Cincinnati and all the little cities which lie contiguous to her are growing enthusiastic over electric roads. Their stocks are regarded the best kind of investments.

The Mt. Auburn Cable Road last week completed and successfully tested an electric line that runs up and down hill for fully five miles, and on Sunday the Covington and Cincinnati Street Railway Company began operating an electric road up grades frequently averaging 10 feet rise in 100. It is now demonstrated conclusively that electric roads are just the thing for rapid transit over and beyond our hills, and both the single trolley and the double trolley systems have proven practicable. The new road to St. Bernard has been opened. It is an extension of the Mt. Auburn Electric Railway. The occasion was celebrated with a banquet. St. Bernard is an old settlement, off the line of the steam railroads by reason of its elevation, and reached heretofore only by one 'bus. The electric road brings thousands of acres of fine residence property into the market and doubles the value of lots.

SOUTHERN NOTES.

NORFOLK, Va., Feb. 14, 1891.

Knoxville, Tenn.—A company has been organized, it is stated, to establish an electric line.

Lake Charles, La.—An electric light plant will be established by J. A. Landry and others.

Union Springs, Ala.—The Union Springs Electric Light Company has recently got its new plant into operation.

Knoxville, Tenn.—An isolated incandescent electric light plant is to be installed in the new Schubert hotel.

Palestine, Tex.—A charter will be petitioned for by the Palestine Electric Light Company, now being formed.

Owensboro, Ky.—A company has been organized, of which C. H. Todd is president, to construct and operate an electric line.

Fort Worth, Tex.—The new electric light plant is about completed, and the city will be illuminated by electricity this month.

Abilene, Tex.—The work of putting up poles, wires and lamps for the Abilene Electric Light Company was completed a few days ago.

Raleigh, Va.—The Western Union Telegraph Company is erecting a new line of telegraph along the Raleigh and Augusta Air Line.

Graham, N. C.—A company is said to be organizing for the purpose of constructing an electrical railway to Buckington, a few miles distant.

Roanoke, Va.—Additional machinery has recently been set up for the electric light plant of the Roanoke Electric Light and Power Company.

Terrell, Tex.—The Terrell Electric Light Company is extending its wires through the city, owing to a large increase in the number of its patrons.

Knoxville, Tex.—An isolated incandescent electric light plant will be installed in the new addition now being erected for the Knoxville woolen mills.

Pine Bluff, Ark.—The Citizens' Street Railway Company has increased its capital stock to $200,000 in order to change its line into an electric system.

Colorado, Tex.—A movement is still vigorously making looking to the organization of an electric light plant company. The mayor of the city can give information.

Pulaski, Va.—The Thomson-Houston Electric Company, of Boston, has been awarded a contract by the Pulaski Iron Company for the erection of an electric light plant.

Radford, Va.—An effort is being made to establish a telephone exchange. The Radford Land and Improvement Company has guaranteed the minimum number of subscribers required.

Newberry, S. C.—A citizens' meeting was held recently to consider the question of lighting the city by electricity, and a committee was appointed to investigate the cost of the enterprise.

V. N. B.

WASHINGTON, D. C., Feb. 14, 1891.

A Lecture on Electric Railways.—Rev. Dr. Clarence E. Woodman delivered a lecture at the Catholic University recently on the subject of electric railways.

A New Charter.—The East Side Street Railway Company has applied for a charter to build an electric street railway. It will be operated by the Momentum engine and the Pole street car motor, the invention of B. C. Pole, an engineer of this city.

Cost of Street Lights.—In the current appropriation bill there is a clause under the head of electric lighting which reads: 'Provided that the Commissioners of the District of Columbia shall investigate and report to the second session of the Fifty-first Congress what deduction may be made for gas and electric lighting both for annual and for five-year and for ten-year contracts, and that they be authorized to invite proposals for supplying said light at reduced rates, and in this they are not limited to any one system.' Since the passage of this bill Capt. James L. Lusk, of the Engineering Department, who has the immediate charge of street lights, has been engaged in investigating. Innumerable letters have been sent to many cities and much valuable data have been obtained. As stated in the clause above quoted, the report must be made to the second session of the present Congress, and was therefore recently transmitted to that body.

E. A. O.

ENGLISH NOTES.

From our own Correspondent.

LONDON, Feb. 4, 1891.

Technical Education.—In the *Times* of Monday there was a joint appeal to the public from the so-called "University Colleges" of London, for the sum of £100,000, to be expended on the promotion of what may be termed University Technical Education. A special committee of the London County Council has also just issued a report recommending that £23,000 should be devoted during the current financial year to the furtherance of technical education in the metropolis, and that a sum not exceeding £130,000 should, in future, be raised for this purpose every year.

The National Telephone Company.—An important meeting of this company was held last week for the purpose of obtaining the consent of the shareholders to the issue of further capital in the shape of £300,000 worth of debentures. From the tone of the chairman's speech and the support given to the proposal, it is evident that neither the board nor the shareholders intend to sit tamely by in face of competition. Indeed it is openly announced that the whole of the £300,000 would be devoted to extending the company's system with a view of keeping competitors at bay. The National Company as your readers probably recollect, absorbed in 1889 the leading companies of the kingdom, and the only companies now outside the sphere of operations, are those which serve the South and West of England, districts by no means favorable for telephony. The nominal capital of the National Company, including the latest proposed issue of debentures is now nearly four and one-half millions sterling, of which some three million has already been absorbed in the undertaking. Two figures will show how lucrative a business telephony is in this country and what a network of interurban telephony has been set up by the National Company. The *net* earnings last year were equivalent to a dividend of 8¾ per cent. on the ordinary shares, and at the end of 1890 244 towns were in telephonic communication with one another.

Overhead Wires in London.—About this time last year our energetic municipal authority, the London County Council, drafted a bill conferring powers upon it for the construction of a complete system of subways, the compulsory removal into these subways of overhead wires, and the regulation of things in general. Before the bill so much as got before Parliament a considerable portion of it was altered, and as it progressed it was entirely transmogrified, so that by the time it was rejected by a majority of three in the House of Commons it was nothing more than a bill for the regulation of telephone wires. With English pertinacity the County Council are again introducing a bill dealing with overhead wires in the metropolis, but it is a very small affair. Wires are only to be erected in accordance with by-laws to be made by the Council, and wherever subways already exist or happen to be built, the owners of overhead conductors may be obliged to place them in the subways, for which compulsory accommodation a reasonable rent is to be charged. Ownerless wires are to be cut down and all wires duly registered. As wires erected by "electric lighting undertakers" and by the Postmaster-General are specifically exempted from the operation of the act, its scope is completely narrowed down to telephone wires. The clause which secured the rejection of the bill last year was one giving power to a "uniformed inspector" duly authorized by the County Council to enter (after reasonable notice and at a time convenient to the occupiers) private houses for the purpose of inspecting or removing overhead wires. This clause still stands in its integrity, and it will be interesting to see whether the House of Commons will be in a more reasonable mood in 1891 than it was in 1890. Like every one else, the House of Commons is agreed that the London local authorities should have the regulation of overhead wires under their control, yet it rejected a bill giving this power, without which any system of regulation must be inoperative.

News of the Week.

THE TELEGRAPH.

The Eastern Telegraph Company, Limited, of London Eng., has issued a little handbook giving maps of the various systems of cable under its control, and the general connections to all parts of the world. These maps contain a great deal of valuable information. Cable messages for this company's lines are taken in this country at offices in Halifax, N. S., Boston, Mass., and New York City.

THE TELEPHONE.

Telephones in Alabama.—The Mobile, Camden and Selma Telephone Company has completed its line from Camden to Alberta, but the line from there to Safford is yet to be completed. It will give this latter place connection with Selma via the Selma, Orrville and Martin Station Telephone Company's line. The lines will be about 50 miles in length.

THE ELECTRIC LIGHT.

Salem, Ind., is to have a $15,000 electric light plant.

Atlantic, Ia.—The electric light plant is now in operation.

Ashland, Va., is agitating the electric lighting question.

Methuen, Mass., is another candidate for an electric light plant.

Delavin, Ill.—The electric light company will soon put in an additional dynamo.

Cameron, Mo., voted unanimously last week in favor of electric lights for the streets.

The Saugerties (N. Y.) Electric Light Company now has its plant in successful operation.

Perth Amboy, N. J., municipality has appointed a committee to consider city electric lighting.

The Middletown (Pa.) Tube Works has increased its plant by one 35 2,000 c. p. arc light dynamo.

Lincoln, Neb., is erecting an electric light and gas plant on a metropolitan scale at the cost of $112,000.

Jamestown, N. Y.—It is expected that the Jamestown electric light plant will be put in operation by June 1.

Jackson, Tenn.—The city will issue $20 000 of bonds to purchase an electric light. The Mayor can give particulars.

The Indiana (Pa.) Electric Company has placed most of its shares and it is expected that the plant will soon be erected.

Mechanicsburg, Pa., has filed a petition at Harrisburg asking for authority to maintain a municipal electric light plant.

The Beardstown (Ill.) Electric Light Company has a natural gas well, and expects to abandon the use of coal in its plant.

Danville, Va.—The Danville Electric Street Car Company's buildings were destroyed by fire last week. The loss was about $16,000.

Cleveland, O.—The magnificent new Arcade Building has its own electric light plant operated by two 100 and one 150 h. p. Ball engines.

Batavia, Ill.—The lighting plant will soon be in operation. The machinery is being put up and the general installation work is being pushed forward.

Large Isolated Arc Plant.—The largest private electric light plant in Philadelphia is at Wanamaker's, which lights 550 incandescent and 472 arc lamps.

Morton, Pa.—William H. Free, of Philadelphia, has made plans for an electric light plant to be built at Morton, Pa., for the Faraday Electric Light Company.

Erie, Pa.—The new Edison electric light station is about completed. It is four stories high. It will furnish power for about 1,800 incandescent and 300 arc lights.

Helena, Mont.—The machinery for the new electric light plant is being put in position, and the manager hopes to have the works in operation in a short time.

The Aspen (Col.) electric light company contemplates building a new flume up the Roaring Fork, which will enable it to obtain ample water power for its machinery.

Japan's 11,000 electric lights are supplied from four stations controlled by the Tokio Electric Light Company. This company also runs plants at Kioto, Keobe, Asaka and Nagaza.

Boston, Mass.—The new Huntington search and fog light, 3,500 c. p., was tested last week from the top of the Edison Electric Light building, and gave satisfactory results.

Le Mars, Ia., wants an electric light plant. This town has been lighted for some time by gas, but electric lights are called for because better light and competition is needed.

Woodberry, Md.—Work has begun on the construction of an electric light station. The plant will be operated by the Woodberry Electric Light Company, which was incorporated recently.

Newburyport, Mass.—A new 500-volt generator is being put in at the electric light works to furnish power for the Thomson-Houston motors that are being installed in several places in town.

Butte, Mont.—The Ball Engine Company, Erie, Pa., has shipped two 150 h. p. tandem compound engines to the Silver Bow Electric Light Company, of Butte, Mont. These engines replace those of another make.

Ashland, Ill.—The city board granted a franchise at its last meeting to C. D. Wright, of Petersburg, to put in electric lights. Quite a number of lights have been subscribed for and by May 1 the plant will be finished.

The Selma (Ala.) Gas and Electric Light Company is installing a 650-light alternating Thomson-Houston machine, which will be in operation shortly. The Mathews cotton mills people are talking of putting a 250-lighter in their mills.

Johnstown, Pa.—The Johnson Company, of Johnstown, Pa., has placed an order with the Ball Engine Company, of Erie, Pa., for five 60 h. p. engines, which are to be used for operating its electric welding machines, now being put in the works.

Chartiers, Pa.—A charter has been granted to the Electric Light Company of Chartiers with a capital of $5,000, and naming Daniel Herely, Robert McMunn, Pressley McMunn, Christopher T. Durhan and John Lee, all of Stowe township, as directors.

Nashville, Tenn.—The machine shops of the Nashville, Chattanooga & St. Louis Railroad at Nashville have recently been completed, and an electric light plant is to be added. The shops cover seven acres of land, and cost in the neighborhood of $850,000.

Cleveland, O.—The cost of lighting the city during 1890 was $168,377.91, divided as follows: Electric light, $21,281.36; vapor lights, $53,576; gas, $93,520.39; new lamp posts, $4,050.55; glass, $4,923.35. During 1889 the gas, lamps, posts and glass amounted to only $93,000. Last year the gas alone reached that figure.

The Florida Electric Light Company, of Tampa, Fla., is erecting an addition to its building, as the demand for light has increased so rapidly that it is almost impossible to build and get machinery in place to meet it. The company is now putting in a large boiler, and expects to have an engine and new dynamo soon.

The Carpenter Electric Light and Power Company, of Cattlettsburg, Ky., has now in operation 600 incandescent lights. Mr. Carpenter, the owner and one of the most noted merchants in the South was in New York this week and purchased a 40-light Westinghouse alternating machine preparatory to installing an arc light system.

Centralia, Ill.—Messrs. Pitteger & Davis have purchased the arc light plant which has been in use here for two years, for the Big Four mine. A lamp will be suspended over the chutes of each of the three roads, which will enable engines to take coal at all hours of the night. This will add much to this already well equipped mine.

To Manufacture Electric Lamp Bulbs in Pittsburgh.—President Dillon, of the Flint Glass Workers' Union, arrived in the city last week from Corning, N. Y., where the workmen are on a strike for a recognition of their organization and for union wages. Mr. Dillon said the attention drawn by the Corning strike to the manufacture of electric lamps would probably start a movement to have lamp factories located in Pittsburgh.

The Detroit (Mich.) Commercial Electric Company has just closed two very large contracts for electric lighting plants one being with J. L. Hudson, of Detroit, for an arc light plant, which includes 200 arc lights of 2,000 c. p. capacity, to be installed in the new Hudson building on Gratiot avenue. It will be one of the finest lighted buildings in the world. The plant will comprise five dynamos, with 40-light capacity each, of the Sperry system of arc lighting, for which the Commercial Electric Company is agent. The company sold to East Tawas an arc and incandescent plant. The two plants cost $30,000.

Mine Lighting.—As an outcome of the recent mine disasters in western Pennsylvania, one of which was about the most terrible happening of the kind on record, a good deal of discussion is taking place with regard to the proper method of lighting mines. The latest scheme is electric illuminating, and it is likely that a bill will be presented to the present Pennsylvania State legislature providing for the use of incandescent lamps in all mines. Several Pittsburgh gentlemen, well qualified to speak, are firmly of the belief that electrical illumination offers the only satisfactory solution of the difficulties at present existing.

The New Albany (Ky.) Gaslight and Coke Company is pushing the work on the extensive additions to its electric light plant, and within a few days will be able to furnish an additional 100 arc lamps, or the equivalent in incandescents, to the public. The company has already contracted to furnish several hundred incandescent lamps to private citizens, and has orders for such a number of arc lights as will use up the greater portion of the capacity of the plant. For some months past there has been considerable talk of the city council taking action in regard to abandoning the use of gas for street lighting in the business portion of the city, and as the company has the contract with the city providing certain conditions are complied with, it is probable that this lighting, which will take 30 arc lamps, will be given to it.

Fairhaven, Wash.—The capital stock of the new electric light, power and motor company is $100,000, and the officers are: Pierce Evans, president; G. A. Black, vice-president; Alex. McKenzie, secretary; John H. Ware, treasurer, and T. W. Gillette, general superintendent. The plant was completed and started on the 10th of last March. Steam power is used, with 225 h. p. capacity, and the company has a fine power house with as modern and com-

plete an outfit as any in existence. There are three arc dynamos with a capacity of 150 lamps, 100 being now in use. Also two large incandescent dynamos with a capacity of 2,000 lamps. The company is rapidly extending its lines into the outskirts of the city, and the service has been most satisfactory to the consumers. Incidentally upon the marvelous expansion of the city, the plant has been enlarged three times within the last six months.

THE ELECTRIC RAILWAY.

The Pittsburgh and Birmingham (Pa.) Electric Road is well under way. The Edison Company has furnished two dynamos, besides a small lighting plant, for the station.

Meadville, Pa., will soon begin work on its electric street railway. Four miles of track will be laid to begin with, and the road is to be in operation by Sept. 1, 1891. The trolley system is to be used.

Southington, Conn., an enterprising town of but 5,400 people, has a two and a half mile electric railway in operation, and the power furnished by the local lighting company costs $1.35 per car a day.

The Worcester and Millbury (Mass.) Electric Railway route has not yet been laid out, but the company is not at a standstill, as $85,000 of the intended capital of $150,000 has been subscribed.

The Boise City (Idaho) Rapid Transit Company has awarded the Edison General Electric Company the contract to finish the entire plant for two and a half miles of electric road, to be completed by June 1.

Pottsville, Pa.—Representatives of the electric railroad company appeared before the town councils of Palo Alto and Port Carbon recently and asked for the passage of ordinances authorizing the construction and operation of the company's road within those boroughs.

The Grand Rapids (Mich.) Street Car Lines have all been bought by a syndicate which has decided to throw out all the cable lines and adopt electric traction. Over 36 miles of road will thus be changed, showing that electricity is rapidly securing its proper recognition.

Pittsburgh, Pa., is to have still another electric street railway. The Citizens Traction Company started work a year ago on a road to the Sharpsburgh, a suburban town, and it was abandoned, but has now been resumed, and it is expected that the road will be completed at an early date.

Ball Engines.—The five 150 h. p. tandem compound engines furnished by the Ball Engine Company, of Erie, Pa., to the Southern Railway Company, of St. Louis, Mo., have given such good satisfaction that Superintendent Harris has placed an order for two more of the same size with this company.

The Lowell (Mass.) and Dracut Street Railway Company is making some changes in its electric line under the direction of W. R. Scott of the Field Engineering Company, of New York. This company and the Lowell Horse Railroad Company have under advisement changing from animal to electric power.

The Central Passenger Railway Company, of Louisville, Ky., is about to increase the power plant by the addition of four 150 h. p. Ball engines and has already placed the order with the Ball Engine Company, of Erie, Pa., for this addition. The company already has six 150 h. p. Ball engines in the generating plant.

Thompsonville, Conn.—The Hartford Carpet Company has now what is said to be the largest private electric light plant in the State. It was completed last week by the Edison Electric Company, and there are 2,300 incandescent lights in the combined circuits. The same company is about to start on a contract to light the streets of the entire town.

The Shenley and Highlands Railway Company, of Pittsburgh, Pa., has been formed to carry on the work begun some time ago by the Squirrel Hill Street Railway Company. The grading for an electric street railway to run from the city to the suburb of Squirrel Hill was commenced a year ago, but was abandoned, as no help was had from the property holders. Power will be furnished temporarily by either the Duquesne or Pittsburgh Traction Companies.

The Suburban Electric Railway Company, which operates a line on the South Side, at Pittsburgh, has decided to invest some money in a power house. Heretofore it has been using power furnished by the St. Clair electric road, but the latter concern, being more of a summer route than an all-the-year-round affair, has shut down leaving the Suburban road in the lurch. The Suburban company taps a large and populous district of the South Side, and will doubtless do a big business once it gets fairly under way with proper facilities.

Allentown, Pa.—The Allentown Passenger Railway, comprising eight miles of a horse car system, owned by New York capitalists, was sold last week to the Industrial Improvement Company, of Boston, Mass. The principal owner of the latter company is the Thomson-Houston Electric Company. The new owners will construct electric roads in Allentown, Bethlehem, West Bethlehem and South Bethlehem, and will connect the Allentown and Bethlehem lines by a branch electric road six miles long, extending through a beautiful section of the country. The several lines will be operated under one system and will be 20 miles long.

The Baltimore Electric Railway to Curtis Bay.—Arrangements are being made for an early construction of an electric railway from some point in South Baltimore to Curtis Bay. The road will be operated by the overhead trolley wire system. The work of construction will be commenced upon the completion of Light street bridge. The road will be about five and a half miles long, and will have two branches—one to Cedar Hill Cemetery and the other to the sugar refinery. There will be two tracks across the bridge. Engineers of electrical companies have been over the route, and are now preparing estimates to bid for the work of constructing and equipping the road.

PERSONALS.

Mr. A. C. Terry read an electrical paper before the Buffalo (N. Y.) Electrical Society last week.

Mr. James H. Mason, of Brooklyn, delivered a lecture, "Electricity," at the Fleet Street M. E. Church last week.

Mr. N. T. Pulsifer, general manager of The Mather Electric Company, is making a two weeks tour of the South and West, and is combining business with pleasure.

Dr. Judson gave a lecture entitled "Electricity in Relation to Physiology" before the Hahnemann Society, of Cleveland, O., recently, which brought out many novel and interesting points bearing upon actions of the will and nerves.

Mr. Herman Hollerith, the inventor of the electrical tabulating machine with which the totals of the census of 1890 were summed up, is a statistician as well as an electrician, and has made census work a special study for several years.

Mr. Otto F. Greim, who has for some time past occupied the position of chief draughtsman with the North American Construction Company, of Pittsburgh, has resigned and will hereafter be found at Greensburg, Pa., where he will be superintendent of the Greensburg and Hempfield Electric Railway. The Greensburg and Hempfield Company operates the Westinghouse system and has been doing a very good business since its cars were started a few weeks ago.

MISCELLANEOUS NOTES.

New York to Boston via the Atlantic Cable.—New York telegraphed to Boston during the recent wreck of the wires by way of the Atlantic cable to England, thence back to Boston.

Photograph printing by Arc Light has been carried out on a small scale recently, blue-prints having been made by exposing the frames under arc lights for a period not much longer than the time required by sunlight.

Industrial and Trade Notes.

Messrs. E. L. Post & Co., of 10 Peck slip, New York, are doing a very good business with their celebrated "Zero" metal, which is especially adapted to electrical uses.

E. A. Wildt & Co., of 83 Murray street, this city, manufacturers of annunciators, bells, door openers, etc., report a very extensive business in these and their other specialties.

Messrs. Green, Tweed & Co., 83 Chambers street, New York, are agents for the Western Carolina Mica Company, which is said to control over 20,000 acres of the best land in this country for mining mica.

A New Switch.—The Great Western Electric Supply Company, of Chicago, is getting out a new switch of novel design, which for simplicity, durability and cheapness is said to rival anything now on the market.

The Cowles Electric Smelting and Aluminium Company, Lockport, N. Y., has issued a price card which places the price list of pure aluminium in lots of 2,000 pounds and over at $1.25 per pound, less 20 per cent. discount.

The Chicago Belting Company, West Randolph street, Chicago, has recently shipped some handsome belts to various street railway companies, among which was one 54 inches in width, one 36 inches in width, and 300 feet of 14-in. belting.

The Kester Electrical Company, of Terre Haute, Ind., has been doing considerable business of late in the installation of its motors and dynamos, the latest installation being the power plant of Messrs. Zimmerman & Stahl's overall factory in that city.

Mr. H. A. Rogers, 19 John street, New York City, handles all kinds of electrical supplies, and is also the sole United States agent for J. Moncrieff's famous Scotch gauge glasses. Mr. Rogers has worked up a large business, and is well known in electrical circles.

The W. Bingham Company, 146 Water street, Cleveland, O., well known as one of the largest wholesale and retail hardware houses in the West, has laid in a complete line of the various electric conductors manufactured by Holmes, Booth and Haydens, and will hereafter carry same regularly in stock.

The Electric Merchandise Company, of Chicago, has just issued a very complete catalogue fully illustrating and describing everything necessary for the complete equiment and maintenance of electric roads of all systems. The first copies of this catalogue will be distributed at the Providence Convention.

Messrs. Chas. A. Schieren & Co., who in September last shipped 160 feet of 72-inch double belt to New Orleans, have received a second order from the same company for a similar belt. They have also recently shipped the Tacoma Railway and Motor Company, of Tacoma, Wash., one 54-inch 3 ply perforated electric belt, besides many other large orders.

The Electrical Supply Company, of Chicago, reports that it is meeting with great success with Sunbeam lamps since it is no longer handicapped by insufficient factory facilities, and can now fill orders promptly and in any quantity. It has reason to feel that the public is realizing the importance of the question, "How much light is returned for every dollar expended in current?"

The Western Carolina Mica Company has lately organized, and owns and controls over 20,000 acres of the richest mica deposits in Mitchell and Yancy counties. The company now operating several mines with steam drills under the superintendence of Messrs. J. K. Irby and J. L. Rorison, who have been known as experts in and miners of mica for the past 15 years. Messrs. Greene Tweed & Co. of 83.

The Pacific Electrical Storage Company, of 220 Sutter street, San Francisco, Cal., is doing quite an extensive business in the installation of accumulator plants on the Pacific slope. A large number of installations have been made during the past year, and 500 accumulators of the type known as the "15 L" are now on their way from the manufacturers to fill orders which the company has on hand. Plants already installed are giving excellent results and consumers are thoroughly satisfied.

Sales of the Fort Wayne Electric Company.—Mr. Thos. Cooper, special agent, and Mr. W. J. Morrison, the company's general agent for New York and Canada, have sold through the Buffalo office of the company in the past six weeks the following plants: Jamestown, N. Y., 120 arc lights; Batavia, N. Y., 120 arc lights; Warsaw, N. Y., 50 arc lights, and 750 alternating incandescents; Niagara Falls, Ont., 60 arcs; United States Electric Light and Power Company, Buffalo, N. Y., 80 arcs.

The New Process Rawhide Company, of Syracuse, N. Y., has received the following letter from the Shaw Electric Crane Company, of Milwaukee, Miss.: "We have had some of your rawhide pinions in use for the past eight months, doing very heavy duty, and find that they show very little wear; while we have used them they have been perfectly satisfactory, and, judging from our present experience, we do not know of anything equal to them in situations in which quiet running at high speed is desirable."

Midget Batteries.—The Electrical Supply Company, Chicago, is selling its "Midget" storage batteries as fast as they can be manufactured. These small 20 ampère-hour cells are said to be as carefully made and as efficient as the larger secondary cells. They are useful for a great variety of purposes, especially in dental and medical work and for small motors and incandescent lamps. They can be charged either from dynamo or primary batteries. They come in hard wood portable cases, in two, three and four-cell sizes.

A Big Business.—It is reported that the Great Western Electric Supply Company, of Chicago, did a very large business in the month of January, and there is every evidence so far this month that the sales will be even greater than the month before. This company, although a new one, has invested upwards of $200,000, and it is claimed that it is the largest exclusive supply house in the United States. It occupies a five story and basement building on Fifth avenue, every floor of which is packed with a complete stock of every kind of goods known to the electrical trade.

A New Trolley Wheel.—A trolley wheel composed of pure aluminium and a composition material has been placed on the market by the Great Western Electric Supply Company, of Chicago. This trolley wheel is very light, only about one-third the weight of brass, has great durability and is said to be very economical. It is said that it does not oxidize or corrode.

The Columbia Incandescent Lamp Company, of 1912 Olive street, St. Louis, has made the necessary addition of improved machinery in its factory which will enable the company to supply all its customers with as many lamps as may be desired. Heretofore customers ordering have been compelled to await their turn, owing to the great demand for "Columbia" lamps, a demand which has been created solely through the intrinsic merit of the lamp, as well as the excellent business methods of the company. Central station companies and owners of isolated plants in the Middle and Western States have found it very convenient to have close at hand a factory so well managed from which they could secure the necessary incandescent lamps on short notice.

The Joseph Dixon Crucible Company, in Jersey City, N. J., makes a silica graphite paint for which is claimed excellent preservative qualities especially adapted to the needs of electric light superintendents, who wish to have the exposed iron work on their line circuits protected from the weather. Recently a piece of iron painted with silica-graphite was suspended for several days in a bath of dilute sulphuric acid, "much stronger than any water met with in mining," yet the painted part, it is said, did not sustain even the slightest blemish. For incandescent line circuits carried through packing houses, breweries and other places where moisture predominates, this paint might prove of great value when applied to insulators and supporting brackets.

The Standard Paint Company, of New York, is just putting into market a number of new compounds, possessing high insulating qualities. They are claimed to be absolutely moisture, acid and alkali resisting, will stand a heat of over 350 degrees F. and a cold atmosphere of nearly zero, without in either case melting or cracking, in this respect being superior to rubber and other insulating materials. Besides they have the elastic qualities to such an extent that the name by which the new insulating material will be known is "Ruberoid" in its solid form and "Ruberine" in its liquid form. In its solid form it can be mixed with rubber quite readily, and is likely to prove a very valuable substitute for rubber. The material will be exhibited at the National Electric Light Convention at Providence, and samples of it will be furnished to parties for practical tests and demonstration. A great many tests have been already made with the material in various directions, and have been eminently tatisfactory.

The Butler Hard-Rubber Company, of New York City, the well-known manufacturers of a most complete line of hard rubber electrical fittings, has now placed upon the market a new composition insulating tubing for which is claimed perfection of insulating qualities as well as durability and absence of excessive sulphur and powdered rubber scrap. This latter point is an important one, as a good degree of vicosity is required when softened for bending. The samples exhibit a hard, glassy vulcanization, and the Western Electric Company have recently made resistance tests of the Butler tubing, the samples for the test having been turned down to 1-32d of an inch in thickness. The tube was filled with mercury, one electrode sealed at the bottom, and immersed in a second electrode of the same metal, either of such electrodes being connected to the Wheatstone bridge. Fifteen thousand megohms is said to have been the resistance of this sample. This enterprising company is as well known in Europe as in America for its electric insulating fittings.

Increase Your Dividends.—Whatever will profitably add to the income of the central station is worthy of careful attention, and the American District Steam Company, of Lockport, N. Y., calls attention to a subject of importance to electric street railway and electric lighting companies enjoying large power. These power stations are usually located adjacent to the best business and resident streets, and by running out from such a station lines of underground steam mains, into which the exhaust from the engines is turned and conducted to the buildings on either side of the streets for heating, at low pressure, this waste product may be utilized. This steam when so used for heating costs nothing either for fuel or for labor at the boiler station, or for office expenses. It is a net addition to the revenue of the company. A Kansas City electric light company is reported to have put down some mains after this plan a year ago, and paid the entire cost for the same from the first season's income. The Ottumwa, Ia., Electric Railway and Steam Company, it is said, put down some two miles of steam mains last year, and is deriving a large revenue from its exhaust steam. Several other electric companies are doing the same thing this year.

Specifications for wiring for electric light employing the conduit system of the Interior Conduit and Insulation Company of New York have recently been issued by that company, and are as follows:

System.—The building to be thoroughly equipped from the source of supply to each outlet with the insulating conduits of the Interior Conduit and Insulation Company, in such manner as to provide continuous channels or raceways for the wires. The continuity of each tube employed for this purpose shall be such as would be required if it were to be used for conveying water or gas. Strict compliance with this requirement will be demanded, since one of the chief advantages of the system herein specified is to exclude water and gas from the wires, and, therefore, afford adequate protection against their deleterious effects.

Accessibility.—To the end that each and every wire may be at all times accessible for inspection, repairs or renewal, the location, sectional divisions, joining, intermediate and terminal elbowing, the placing of switches, cut-outs and junction boxes and the final emergence of the tube beyond the finished surface at the fixture outlet, must be done in strict compliance with the rules and regulations herein contained.

Appliances.—In order to secure safety, durability and convenience and to give a finished character to the work, all appliances employed shall be such as are designed especially for use in conjunction with this system.

Subdivision of Risers.—The building must be divided into a number of sections, and each section provided with an independent group of risers, thus avoiding the multiplication of elbows, intersection boxes and long runs of the taps or branches. Every conductor in each group of risers must be provided with an independent tube.

Branches.—For all branches the standard twin conductor of the Interior Conduit and Insulation Company, requiring but one tube, must be employed. The current limit of the branches must be that fixed by the Fire Underwriters' rules.

Size of Tubes.—All tubes must be of sufficient size to allow the wires to be readily drawn in, withdrawn and reinserted at will. A quarter (¼) inch tube will be permitted only where space is extremely limited, as under a thin plaster finish.

Clips.—Tubes, whether concealed or on the surface, must be held in place by metal "clips"; the use of staples for such purpose will not be allowed where it can be avoided.

Joints.—The tubes must be cut squarely and then reamed out smoothly and the ends joined in the manner and by the use of the corrugated coupling designed for that purpose.

Elbow Limitations.—Where more than four elbows are unavoidable an intersection box must be inserted to relieve both the wires and the tubes of strain when the wires are being drawn in.

Outlets.—All tubes must emerge at outlets in terminal boxes, thus leaving the outlets so protected as not to be injured by the plasterers.

Fixture Supports.—Where no gas pipe or other support for the fixtures exists, the special form of terminal box designed to furnish such support must be employed, and must be substantially fixed to a suitable foundation in the ceiling or walls.

Junction Boxes.—Main circuit junction boxes must be placed on each floor in each section; from these junction boxes all branches in the section must ramify.

Cut-Outs.—Standard non-combustible cut-outs must be used within the junction boxes, and each branch wire leading from the same must be protected by a safety fuse.

Floor Work.—To guard against mechanical injury and the destructive action of cement all floor conduits must be made of double tube, one telescoped within the other, and both the outer and inner tubes joined in the usual manner. The outer tube must, in the case of contact with cement, be alkali proof. As a further protection all floor tubes must be covered during construction with a light board.

Wires.—For mains a conductor having an insulation known as "fire and waterproof," and for branches the standard twin conductor of the Interior Conduit and Insulation Company, must be used.

Annunciator Wiring.—All annunciator or bell wires must be placed within conduits, and such of the foregoing rules and regulations as are applicable to rendering them accessible and affording suitable protection shall be followed.

Inserting Wires.—After the conduiting is completed powdered soapstone must be blown into the tubes in order to facilitate the drawing in of the wires.

Inspection and Acceptance.—As a guarantee that the wiring will be properly done, it is required that the contractors, in event of their being unfamiliar with the system, communicate with the Interior Conduit and Insulation Company of New York, or their authorized representatives, and obtain the requisite instruction. The right is reserved to subject the work of the contractor to the inspection and approval of the Interior Conduit and Insulation Company as a condition of acceptance and final payment.

Business Notices.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren street, Syracuse, N. Y.

BLOOMINGTON ELECTRIC LIGHT CO.,
BLOOMINGTON, ILL., July 26, 1890.

Shultz Belting Co., St. Louis:

GENTLEMEN: Replying to your recent inquiry as to "how we like your pulley cover," will simply say that it is a "godsend" to us this hot weather; would not be without it for ten times the cost. We are using 50 per cent. less oil on our bearings than heretofore. I believe it also saves power and fuel. It certainly has saved considerable worry and mental anxiety. No company or individual can afford to run an alternating dynamo without it.

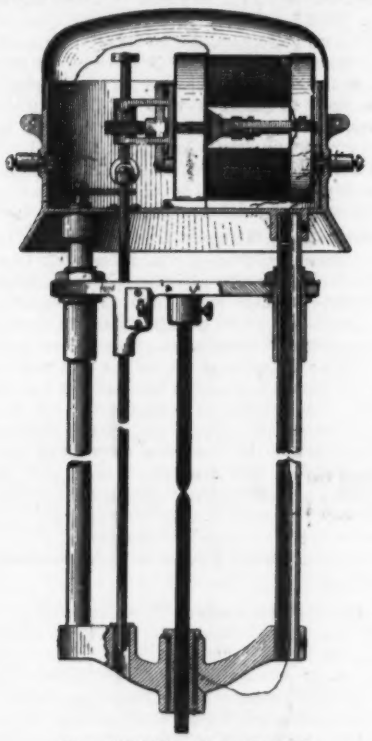
Respectfully yours,
BLOOMINGTON ELECTRIC LIGHT CO.
J. H. MILLER, Supt.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS

U. S. PATENTS ISSUED FEB. 10, 1891.

445,969. Electric Insulator; James R. Branch, of Richmond, Va. Application filed May 20, 1890. An insulator having a flat base to be secured upon a support with straight sides or periphery, an inwardly and upwardly extending groove around the periphery of the insulator, forming a downwardly-extending edge a distance above the base of the insulator, and a clip insulated from and securing the conductor on to the top surface of the insulator.

445,991. Electro-mechanical Indicator for Fire-alarm Telegraphs; Thomas F. Gaynor, of Louisville, Ky., Assignor to

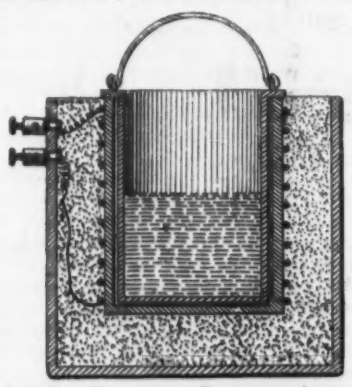


NO. 446,109.—ARC LIGHT.

the Gaynor Electric Light Company, of same place. Application filed May 15, 1890. In combination with each one of a series of figured drums of an indicator, an escape-wheel, a pivoted pallet-lever having two loosely pivoted pallets thereon adapted to engage with the escape wheel, each having a slot in which a corresponding pin in the pallet lever plays and by which their movement is controlled, and a spring secured to the pallet-lever, adapted to press the pallets towards each other against the escape wheel.

446,030. System of Electrical Distribution for Mines. Application filed April 1, 1889. In a system of electrical distribution for mines, the main conductor leading down the main entries, branch conductors leading down the butt-entries derived from said main conductors, and ammeters located at the junctions thus formed, in combination with machines for both mining and transporting, deriving their energy from the same wires.

446,031. Electric Switch; Elmer A. Sperry, of Chicago, Ill. Application filed July 2, 1890. In a contact-making device, a flat oscillating or vibrating spring forming one contact secured to the base, having a bent portion near this end and a straight por-



NO. 446,174.—ELECTRIC COOKING APPARATUS.

tion near the other end acted upon by a rotating oblong cam, and a flat spring set at an angle thereto, forming the other contact.

446,092. Dynamo-Electric Machine and Electric Motor; Edward K. Brown, of Brooklyn, N. Y., Assignor by direct and mesne assignments to himself and Geo. Phillips, of same place. Application filed Nov. 1, 1889. A dynamo-electric machine having a coil and two similar sections composed of laminæ of substantially the same form, each of which sections constitutes a pole-piece and part of a core, the parts of the two sections constituting the core being received within the opposite ends of the coil.

446,104. Electrode for Secondary Batteries; Marmaduke M. M. Slattery, of Fort Wayne, Ind., Assignor to the Fort Wayne Electric Light Company, of same place. Application filed April 6, 1889. An electrode for secondary batteries formed of finely-divided pure copper compressed into a coherent mass.

446,108. Electric Arc Lamp; Richard H. Mather, of Windsor, Conn. Application filed Jan. 24, 1887. In an electric arc lamp having a rotary sleeve consisting of two parts, which are provided with radiating pins or arms and are united by a joint allowing independent rotation of said parts, and a locking sleeve which surrounds said rotary sleeve and is adapted to engage the pins.

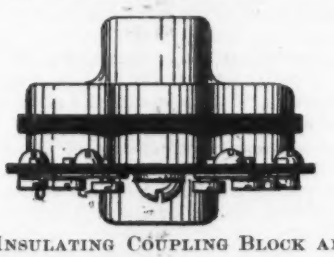
446,109. Arc Light; Richard H. Mather, of Windsor, Conn. Application filed Oct. 11, 1886. An electric arc lamp comprising a movable carbon carrier, a reversable electric motor whose field magnet is excited by two helices in series, and whose armature is located in a derived circuit, and a compound switch having separate connections with said armature and with the field magnet circuit upon opposite sides of the field magnet, and mechanism for transmitting motion from said armature to the carrier.

446,130. Lightning Rod; George W. Downey, of Hyattsville, Md. Application filed Oct. 15, 1890. This invention consists in a lightning rod section, comprising a strip of sheet copper angularly bent and twisted into spiral form and having corrugations between its angles and a small space between the adjacent edges of the said strip of metal.

446,142. Electric Signal and Search-Light Lantern; George W. Martin, of Somerville, Mass., Assignor of one-half to Josiah Knight, of same place. Application filed Feb. 28, 1890. In a lantern, a tapering body, having at its smaller end a flange and screw-threaded neck and at the larger end a concavo-convex front provided with a lens, all in one piece of glass, combined with a screw-threaded metal sleeve, a socket, and an electric lamp, said socket supporting the lamp and adapted to connect to said sleeve, the tapering exterior of the body being covered with a reflecting material, the latter covered with a protective coating.

446,159. Switch and Signal Apparatus; George Westinghouse, Jr., and Jens G. Schreuder, of Pittsburgh, Pa. Application filed March 19, 1888. The invention consists in certain combinations of rotable or revoluble rollers or barrels, some of which are connected to valve mechanisms controlling the operation of switches and themselves dependent for full movement upon the switch movements, said rollers being provided with insulated metallic strips so located around the barrels or rollers as to require certain predetermined positions of certain predetermined rollers for the completion of the controlling electric circuits. It also consists of mechanism for locking switch-operating levers, said mechanism being operated by the signal levers, which are in turn locked by electrically-controlled mechanism by the clearance of a signal and unlocked by the passage of the train from the section controlled by the cleared signal.

446,174. Electric Cooking Apparatus; Jeremiah O'Meara, of New York. Application filed May 1, 1890. A portable heating apparatus comprising an enameled vessel, a heating coil of German silver, or other electrically-conductive wires surrounding



NO. 446,180.—INSULATING COUPLING BLOCK AND CUT-OUT.

the said enameled vessel externally, and an external electrically non-conductive casing surrounding the wires. (See illustration.)

446,180. Insulating Coupling-Block and Cut-Out; Sigmund Bergmann and Charles J. Klein, of New York, said Klein assignor to said Bergmann. Application filed March 11, 1890. A coupling-block and cut-out, comprising a section having a tubular boss to engage a pipe, another section having a tubular boss to engage a fixture, with insulating material between said sections, a disc of insulating material having a central opening to pass over the boss of the last-named section, the said disc extending laterally beyond said sections, and having openings for the passage of main wires outside of the sections, screws passing through the disc and sections securing the parts together, pairs of connecting plates secured to the disc on its outer side, binding posts on the plates, and fusible wires. (See illustration.)

446,188. Telephone Transmission; James McDonough, of New York. Application filed Aug. 28, 1885. A transmitter responsive to sound vibrations of any kind, and a dynamo-electric or magneto electric machine, whose field is maintained by an electric current variable through the action of said transmitter, while its armature, operated by any suitable power, delivers a current that is utilized directly or indirectly in operating upon a suitable receiver.

446,200. Fire Indicator and Extinguishing System; Stephan Broichgans, of Milwaukee, Wis. Application filed Oct. 29, 1890. In a fire indicator and extinguisher system, a dial and pointer, the latter having its arbor provided with a pinion, a spring controlled bell-crank, provided with a rack in mesh with the pinion, a pivoted lever having an arm linked to the bell-crank, a series of spring-controlled fingers opposed to the lever, electrically-actuated latches for engagement with the fingers, and a stop arranged to limit the movement of each of said fingers.

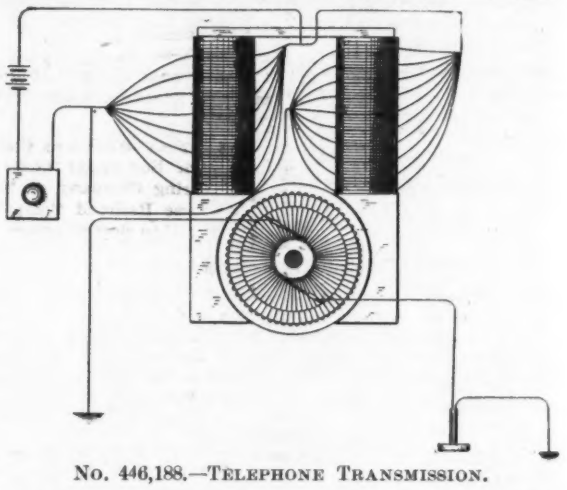
446,214. Method of Laying Electric Cables; Charles H. Wilson, Chicago, Ill. Application filed Sept. 19, 1888. The invention consists in blocks or wedges as used in the conduit for the purpose of arranging the cables in line throughout the length of the duct, so that one cable may be drawn in after another without obstructing and without abrading one another, and so that any cable may be drawn out likewise without injury or unnecessary friction.

446,229. Regulator for Electric Motors; Lander S. Harris, of Detroit, Mich. Application filed Aug. 30, 1890. An electric motor for constant potential circuits, having its field magnets wound with a shunt circuit over the field magnets alone and its armature wound with another shunt circuit over the armature alone, and in connection therewith independent circuits in parallel arc, with each other, of different grades of wire, passing over the field magnets and directing their current thence over the armature circuit with switch mechanism for bringing said latter shunt circuits successively into and out of action as the machine is being started.

446,245. Electric Locomotive; George Reade Baildwin, of Montreal, Canada. Application filed July 17, 1890. A traction apparatus having the motor rigidly attached to the motor truck, the main driving shaft geared to said motor and mounted in bearings on the motor truck, two pairs of traction-wheels keyed on their respective axles and supporting the motor trucks, boxes mounted and rotatable on said axles, flexible extensions to the main driving shaft, having their inner ends connected to said main shaft by universal joints and their outer ends stepped in the above-mentioned rotatable boxes, and gearing connecting said flexible shaft extensions to the axles of the traction wheels, together with the reversing-gear in the line of connections from the motor to the main driving shaft.

446,284. Automatic Potential-Regulator for Electric Currents; Alvirus 'Lonza Ellis, of Kansas City, Mo. Application filed July 3, 1890. The invention consists in the combination, with a potential regulating device of known construction, of a pair of electric motors connected with the potential-controlling devices and with the main circuit, and a circuit-controlling magnet and armature arranged to send the current to one or the other of the motors, thus operating the potential-controlling device in accordance with the requirements of the circuit.

446,297. Electric Arc Lamp; Carl Joseph Schwarze, of Brooklyn, N. Y. Application filed Oct. 2, 1890. An electric lamp having a wheel mounted loosely on a shaft, said wheel being formed with a toothed rim, and having independent cords en-

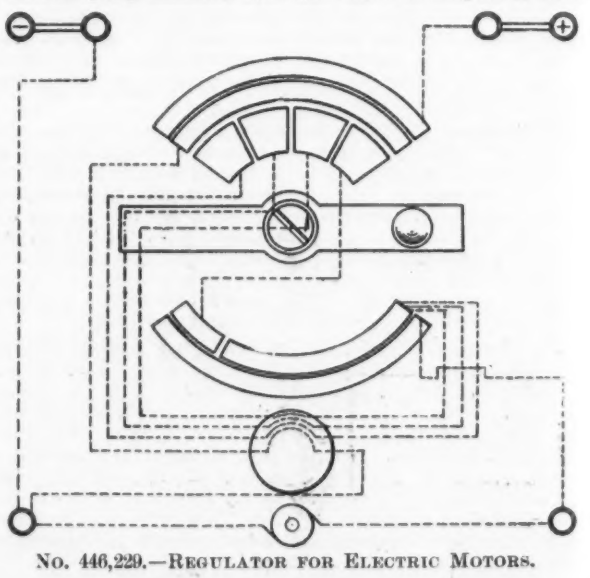


NO. 446,188.—TELEPHONE TRANSMISSION.

gaging opposite sides of the wheel and winding and unwinding in reverse directions. The carbon holders are suspended by these cords.

446,298. Arc Light System; Carl Joseph Schwarze, Brooklyn, N. Y. Application filed Oct. 9, 1890. An electric arc lamp having a magnet for automatically maintaining the normal arc when the lamp is burning, and an opposing magnet for changing the normal arc of the lamp, a switch for throwing the opposing magnet in and out of the circuit, and suitable connections with a dynamo machine or other source of electricity.

446,313. Electrical Signal System for Railroads; Edgar C. Wiley, of Bristol, Tenn. Application filed Nov. 13, 1890. In a circuit-closing device for railway systems, a commutator cylinder and contact brushes, a block located on one of the journals of said cylinder, a pivoted arm below said block to latch it and a curved spring connected with said arm and adapted to be de-



NO. 446,229.—REGULATOR FOR ELECTRIC MOTORS.

pressed by the car wheel to release said block and permit the cylinder to be turned.

446,376. Electric Railway and Contact Device Therefor. Application filed Sept. 20, 1888. An electric railway, having two converging tracks uniting in a single track at a switch, and conduits containing supply conductors for the respective tracks joining into one at a point near the switch, and both placed without and on the same side of their respective tracks, with their slots a uniform distance from the corresponding track-rails, so as to permit a vehicle to travel on either track without shifting of the contact device.

446,403. Track Instrument for Railway Signals; Mahlon S. Conly, of Chicago, Ill. Application filed June 5, 1890. A track instrument for electric railway signals, having the rail and track instrument secured thereto, and a bar rigidly secured at both ends to the rail and connected with the track instrument so as to operate said instrument by the movement of one of the members relative to the other.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.